LOWER MUYEMBE

MICRO-CATCHMENT CLIMATE RESILIENT ACTION PLAN

Ministry of Water and Environment

Water Resources Planning and Regulation (WRPR) Department

MARCH 2026

APPROVAL AND ENDORSEMENT SIGNATURES

Lower Muyembe Micro-Catchment Climate Resilient Action Plan (CRAP) was prepared, reviewed, and validated by the local communities, the Micro-catchment Management Committee, and the District Local Government (DLG), with technical support from the Ministry of Water and Environment (MWE) - SACRiAC project. It is hereby approved for implementation on this _____ day of March, 2026.

1. Lower Muyembe Micro-Catchment Management Committee

Acknowledged for community-level validation and technical review.

Name	Signature	Date
BUSIKU SIMMY		18/03/2026

Chairman, Lower Muyembe Micro-Catchment Management Committee

2. Awoja Catchment Management Committee

Endorsed for alignment with the broader Awoja Catchment Management Plan.

Name	Signature	Date
EJUNYU GEORGE MICHAEL		18/03/2026

Chairman, Awoja Catchment Management Committee

3. Bulambuli District Local Government (DLG)

Approved for administrative implementation and integration into the District Development Plan.

Name ..... NANDUDU ANNET

Signature: .....

Date: 18/03/2026

District Chairperson (LC V)

Name ..... OLOL CHARLES

Signature: .....

Date: 18/3/2026

Chief Administrative Officer

BULAMBULI DISTRICT LOCAL GOVERNMENT
18 MAR 2026
email:caosofficebulambuli@gmail.com
CHIEF ADMINISTRATIVE OFFICER

FOREWORD

Climate change remains one of the most significant challenges to Uganda's ecosystems, water resources, and the collective wellbeing of our people. As we advance toward **Vision 2040** and implement the **National Development Plan IV (NDP IV)**, it is our duty to strengthen the resilience of the most vulnerable regions through evidence-based planning and community-driven action. The Ministry of Water and Environment is firmly committed to the sustainable management of our watersheds. Our goal, as outlined in the Strategic Development Plan (2025/26 – 2029/30), is to achieve "Sustainable development and management of water and environmental resources for climate resilience and socio-economic transformation."

The preparation of Climate Resilience Action Plans (CRAPs) at the watershed and micro-catchment levels marks a transformative milestone. These plans are not merely documents; they are practical, community-led guides designed to help local governments, and institutions: anticipate climate risks through improved data and early warning systems; restore degraded ecosystems, including vital wetlands and riverbanks; and build technical capacity to ensure that investments in water and environment yield benefits for generations to come.

Hon. Sam Cheptoris
Minister of Water and Environment
The Republic of Uganda

I extend my sincere gratitude to our development partners, district authorities, technical experts, and the local communities whose dedication brought the Lower Muyembe Micro-Catchment Climate Resilience Action Plan (CRAP) to fruition. Their collaboration embodies the spirit of the **National Climate Change Act**.

As we move into implementation phase, I call upon all stakeholders —from government agencies to the private sector— to champion implementation of this CRAP. Together, we can secure a healthier, more productive, and climate-resilient Uganda for all.

For God and My Country

ACKNOWLEDGEMENT

Dr. Alfred Okot Okidi
Permanent Secretary
Ministry of Water and Environment

The development of the Lower Muyembe Micro-Catchment Climate Resilience Action Plan (CRAP) marks a decisive operational shift in Uganda's strategy to reverse catchment degradation, and boost ecosystem productivity. While the Minister has set the strategic direction, the realization of this plan is a testament to the technical rigor and seamless collaboration of our dedicated teams and partners.

I wish to recognize the exceptional leadership of Dr. Callist Tindimugaya, Ag. Director of Water Resources Management, and the Kyoga Water Management Zone Team led by Eng. Maximo Twinomuhangi. Their ability to translate national policy into micro-catchment realities has ensured this plan is both scientifically sound and locally relevant.

Our progress is significantly bolstered by the strategic partnership and financial support of the Global Environment Facility (GEF) and African Development Bank (AfDB). I specifically commend the SACRiAC Project Team, under the coordination of Dr. Felly Mugizi Tusiime, alongside the Contract Management Team—Itenu Irene Adongo, Wanga Benjamin, and Arinaitwe Topher—for their meticulous execution of this complex planning process.

This initiative's strength lies in its multi-sectoral nature. I am grateful for the technical contributions from the government and national authorities: National Environment Management Authority (NEMA), Uganda Wildlife Authority (UWA), the former National Forestry Authority (NFA), Buginyanya Zonal Agricultural Research and Development Institute (BugiZARDI), the Office of the Prime Minister (OPM) and Bulambuli District Local Government; the private sector, Kyagalanyi Coffee Growers' Association; traditional institutions, (Office of the Umukuka) and the Awoja Catchment Management Committee led by Mr. Egunyu George Michael.

Most importantly, I thank the community members who grounded these plans in reality. Your lived experiences with climate shocks provided the "evidence" in our evidence-based approach.

As the accounting officer, I now urge all stakeholders to transition from planning to urgent implementation. This CRAP is our roadmap to safeguarding livelihoods and restoring the natural capital upon which our nation's future depends.

For God and My Country

FOREWORD BY THE DIRECTOR, DIRECTORATE OF WATER RESOURCES MANAGEMENT

Dr. Tindimugaya Callist

Ag. Director, Directorate of Water Resources Management (DWRM)

Uganda's water resources are under unprecedented pressure from climate variability, rapid population growth, and unsustainable land-use practices. As these challenges intensify, the transition toward **Catchment-based Water Resources Management (CbWRM)** has never been more critical.

The development of this Climate Resilience Action Plan (CRAP) - under the *Strengthening the Adaptive Capacity and Resilience of communities in Uganda's watershed – Awoja Catchment (SACRiAC)* Project - represents a major technical milestone in securing our nations hydrological future.

While infrastructure is a visible sign of progress, its longevity depends entirely on the institutional and technical capacity of the structures that manage it. By developing both watershed-level and micro-catchment-level CRAPs, we have ensured that our interventions are spatially targeted and grounded in local realities.

This plan is a result of rigorous hydrological modelling, climate-risk profiling, and **multi-spectral land-use assessments**. The plan provides a clear, evidence-based roadmap for: **restoring vital ecosystem services** through riverbank and wetland rehabilitation; scaling Climate-Smart Agriculture (CSA) and soil conservation to protect our water quality; **Disaster Risk Management** to mitigate the increasing frequency of floods and landslides in priority basins; and livelihood diversification to reduce community over-reliance on fragile natural resources.

The CRAP is not a static document; it is a dynamic strategic tool designed to coordinate multi-sectoral action and direct investment where it is most needed. The plan bridges the gap between high-level climate science and actionable, community-led resilience.

I commend the technical teams, our development partners, and the local government structures for their commitment to this technically robust process.

The Directorate of Water Resources Management (DWRM) remains fully commitment to providing continuous technical guidance and monitoring required to translate the CRAP into measurable landscape restoration and improved community wellbeing. I urge all stakeholders to adopt this framework with the urgency our changing climate demands.

For God and My Country

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LIST OF ACRONYMS/ ABBREVIATIONS

AfDB	African Development Bank
AEZ	Agro-Ecological zone
CBOs	Community Based Organizations
CDO	Community Development Officer
CMC	Catchment Management Committee
CMO	Community Management Organization
CMP	Catchment Management Plan
CMS	Catchment Management Secretariat
CRAP	Climate Resilient Action Plans
CRiSTAL	Community-based Risk Screening Tool – Adaptation and Livelihoods."
CTC	Catchment Technical Committee
DWD	Directorate of Water Development
ESMP	Environmental Social Management Plan
GEF	Global Environment Facility
GFS	Gravity Flow Scheme
GoU	Government of Uganda
GPS	Geographical Position System
IWRM	Integrated Water Resources Management
KWMZ	Kyoga Water Management Zone
LC	Local Council (I, II, III and V)
M&E	Monitoring and Evaluation
Masl	Meters Above Sea Level
MCA	Multi Criteria Analysis
MCMC	Micro-catchment Management Committee
MWE	Ministry of Water and Environment
NAPA	National Adaptation Programme of Action
NEMA	National Environmental Management Authority
NGOs	Non-Governmental Organizations
SACRiAC	Strengthening the Adaptive Capacity and Resilience of Communities in Uganda's watersheds – Awoja Catchment
SSEA	Strategic Social and Environment Assessment
SCMC	Sub-Catchment Management Committee
SEP	Stakeholder Engagement Plan
ToRs	Terms of Reference

UBOS	Uganda Bureau of Statistics
WMZ	Water Management Zone
Yr	Year

EXECUTIVE SUMMARY

Lower Muyembe Micro-catchment covers an approximate total area of 49.55 km^2 in both Bulambuli and Kapchorwa districts. The Micro-catchment consists of the following administrative units: Amukol Sub-county, Buginyanya Sub-county, Bulambuli T/C, Bulegeni Sub-county, Bulegeni T/C, Bumugibole Sub-county, Chepteret Sub-county, Kamu Sub-county, Kapsinda Sub-county, Kaserem Sub-county, Kawowo Sub-county, Masiira Sub-county, Muyembe Sub-county, Nabongo Sub-county, Sipi Sub-county and Sisiyi Sub-county.

The Micro-catchment is located within the Muyembe Sub-catchment which is part of the greater Awoja catchment of approximately 11,000 km^2. The Greater Awoja catchment straddles in over 14 districts (Katakwi, Nakapiripirit, Amudat, Kumi, Amuria, Soroti, Serere, Ngora, Bukedea, Sironko, Bulambuli, Kween, Bukwo, and Kapchorwa). It lies in the Kyoga Water Management Zone under the decentralized water resources management in Uganda. Lower Muyembe is therefore a Micro-catchment within Muyembe sub-catchment.

Generally, the area exhibits high soil erodibility with moderate rainfall. Soil erosion and siltation are undeniably a major environmental risk in the micro-catchment and will be the dominant consideration in soil and water conservation management.

The Micro-catchment, the areas are veldt in sections of Mountain Elgon National Park and forest Reserve composed of overstorey and understorey of Pine (*Pinus caribea* and *Pafuta*) and Eucalyptus plantations. Agricultural landscapes are distinctly defined with built-up areas, croplands (Irish potatoes) and Syzygium on some sections of the river banks.

The most recent mudslides occurred on November 27, 2024 and November 30, 2024. They led to loss of lives, destruction of infrastructure like bridges, roads, schools, houses, etc. and displacement of people. Lower Muyembe Micro-catchment mainly suffers the effects of Flooding, mud and landslides the most recent occurrence being in November 2024 that led to death of unaccounted for people, displacement of many households and destruction of property and gardens. The identified hotspots being Bulegeni, Buginyaya, Nabongo and Muyembe. Uganda experiences both flash and slow onset floods. They are common in low lying areas and areas along river banks and close to wetlands. They may also occur along lakes or more permanent wetland shores lower in the basin when El Nino episodes led to strong water level increase as in 1997-98. Lower Muyembe Micro-catchment experiences mild to moderate droughts with severe droughts being very rare.

The Micro-catchment has a moist to moderately dry climate with an average annual rainfall of 3,000 mm. The region experiences a bimodal rainfall pattern, with peaks during the long rains (March-June) and short rains (September-November).). In comparison to the baseline scenario, the peak flows will increase by an average of about 13%, 30%, 39%, and 76% for the climate change emission scenarios SSP2-4.5 (by mid-century), SSP5-8.5 (by mid-century), SSP2-4.5 (by end of century), and SSP5-8.5 (by end of century), respectively. The results further indicate that the climate change high emission scenario (SSP5-8.5) will have higher impacts than the climate change moderate emission scenario (SSP2-4.5).

Water use in the catchment included domestic water use and especially the population of urban areas of Bulambuli and Kapchorwa that are over populated and the rural area of the same district. institutional water use (schools, hospitals, government institutions and markets). Water balance projections up to 2050 indicate satisfaction of the catchment water resources with withdraws of up to 23.68% of available water, below SDG 6.4.2 and FAO's physical water

scarcity level at 75%. Per capita water availability (1743.08 m^3/person/year) within the microcatchment was above the Falkenmark threshold water stress implying that the micro-catchment is not either physically or economically water scarce.

The Catchment was found to be predominantly a rural setting. Most dominant LU/LC identified are Forest, Grassland, and Agricultural. The Micro-catchment are found to be predominantly a rural setting. In the time series covered, most dominant LU/LC identified are Forest, Grassland, and Agricultural. The significant drivers of LU/LC change are grouped into institutional, economic, and natural factors. Institutional factors that contributed to LU/LC changes in the catchment include government programs like water for production operation wealth creation, the national agricultural advisory services (NAADS), National Agricultural Research Organisation (NARO) and policy frameworks like development of irrigated agriculture.

The assessment identified a distribution of key business enterprises comprises of crop farming, livestock production and, agricultural produce trade, transportation, sand mining, brick making and laying, livestock keeping, craft making, carpentry, bakery, timber dealing, charcoal burning, bee keeping. The crops grown include; bananas, coffee, maize, fruits (jackfruit, mangoes), cassava, beans, avocados, vegetables (tomatoes) (onions), and ground nuts. The enterprise chain consists of crops and livestock. The livestock value chain relatively small compared to the crop value chain. The crop enterprise value chain is composed of 3 channels:

- farm to produce market and the retail market as the main channel
- local processing that handles farmers produce such as coffee and maize
- traders buying produce from farmers or farmer associations and transporting the produce to larger urban markets and/or larger processors. The trade value chain mainly focuses on grain crops, such as maize, beans and rice, though also other food crops are in this trade value chain that is Matooke, tomatoes and onions.

The micro-catchment cuts across important and biologically diverse ecosystems with a diversity of species of conservation concern. In a way, all these species are dependent on the catchment for water while other water dependent species entirely rely on the catchment for their survival. These include mammals such as the elephants, bush bucks, duikers and rodents, birds especially black collard Apalis, Jackson's Francolin. As Mount Elgon National park is a biodiversity hotspot, supporting a wide range of animal species due to its diverse ecosystems. The park's varied habitats, from savannah landscapes to dense montane forests, bamboo forests and moorlands, offer unique niches for various animals.

A number of options and activities were identified from the SSEA and can be categorised as:

- Governance of water management
- Management and coordination of economic activities
- Management of Water resource allocation including domestic water use, hydropower and irrigation and environment.
- Addressing climate change impacts
- Infrastructure development and management

Overarching challenges in the Micro-catchment identified during the study include flooding, intense farming practises on landscapes, deforestation, poor water quality, poor waste management (legacy stock piles), encroachment on the river banks, unsustainable water

diversions, land and mudslides, land fragmentation, problematic animals, poor infrastructure, institutional capacity, and a number of gender issues.

Based on the plethora of the knowledge base and those existing challenges, assessment of linkages, cumulative impacts, and in realisation of the Uganda Vision 2040, a micro-catchment vision was developed with the involvement of stakeholders:

"To create sustainable, manageable and bankable strategies geared towards improving productivity, equitable and sustainable use of natural resources to foster enhanced livelihoods and climate change resilience by 2035"

To achieve the vision and strategic objectives, there was need to undertake measures which address the main issues and reverse those trends that undermine sustainable development in Sironko sub-catchment. These measures are referred to as options.

A range of potential options to consider in the CRAP were gathered from Stakeholder consultations, focus group discussions, community engagements, workshops, situation analysis, and literature review to support the identification of intervention opportunities that contribute to the achievement of the vision, Mission and the strategic objectives.

Options and scenarios were evaluated based upon socio-economic, environmental, institutional and financial criteria and discussed with the stakeholders. The analysis of the benefits and costs of the three scenarios shows that a single set of options cannot meet the strategic objectives. No-regret measures amplified with investment and management actions of the scenarios of "Environmental Conservation and Protection", "Water Resources Infrastructure development" and "Enhanced community resilience to climate change" must be combined. Only by integrating the different scenarios can water resources' use and management benefit the people in the short term and be sustainable in the long run. Based on the outcomes a maximum-benefit scenario was formulated and corresponding interventions were articulated along four thematic areas.

Institutional strengthening and capacity development thematic area cuts across the other three thematic areas. It concerns all levels (national, regional, local and community) and involves policy enforcement, regulatory measures, streamlining of procedures, systems and structures, stakeholder involvement in decision making processes, access to information and data, coordination and dialogue within and between sectors, and integration of traditional management practices into governmental guidelines".

Large part of foreseen investment and management actions in the CRAP are common to all scenarios identified in the option analysis, while some actions are directly related to the best evaluated scenario 1. Identified catchment management and investment actions include;

a) Sustainable land and Environmental management
b) Climate resilient bridges
c) Multipurpose Storage dams
d) Rural Water Supply and Sanitation Schemes – Gravity flow schemes
e) Waste management facilities
f) Foot bridges

Besides these actions, No-regret measures have been identified. A large part of actions interests most of the catchment, while other actions are supposed to be implemented only in some areas, according to specific characteristics of different sub-catchments. For some actions, priority areas of intervention have been identified taking into account knowledge base,

most critical key issues and identified opportunities during option analysis. For these actions the investment costs for implementation only in priority area were estimated, in order to allow an easier selection of actions to be implemented first, according to budget availability.

The priority does not indicate the relevance, but rather an order of implementation in time. The priority is indicated as “critical”, “high”, “medium” and “low”. Critical are activities for which implementation should start immediately, high are activities of high relevance to key issues and with expected high impact on improving water resources management and stopping harmful practices. Critical and high priority actions have to be implemented at short term (1-3 years). Medium priority is set for activities that are planned to be implemented at medium term, within 3-5 years from CRAP approval. Activities with priority set at “low”, can be implemented in the longer term, meaning within 5 to 10 years from the approval of the CRAP.

Pre-feasibility studies were carried out for each management and investment action identified in the “Best scenario”. A list of identified, confirmed and quantified priority catchment management investments are prepared and costed, to easily attract donors and budget allocations to support plan implementation. The project is characterized location, number of beneficiaries, estimated costs, time frame, and sources of funds, community contributions and development partners as indicated in the Table below.

Project Name	**Micro-catchment Bankable Projects**
Location	Lower Muyembe Micro-catchment
Number of Beneficiaries	120,000 people (2035)
Estimated Cost	USD 43,225,000
Time frame	Short Term (1-3 years), Medium Term (3-5 years), Long Term (5-10 years)
Source of Funds	▪ Bulambuli and Kapchorwa District Local Government ▪ Ministry of Water and Environment (MWE) ▪ Ministry of Tourism, Wild life and Antiquities (MoTWA) ▪ Ministry of Works and Transport (MoWT) ▪ Ministry of Agriculture, Animal Industry and Fisheries (MAAIF) ▪ The Fourteen (14) Sub-counties and two (02) town councils ▪ The Prime Minister’s Office (OPM)
Community Contribution	Land, Unskilled labour, materials, maintenance, monitoring and Evaluation
Development Partners	AfDB, World Bank, GoU, GEF, Green Climate Fund, UK Department for International Development (DFID), private sector like Kawacom

The CRAP is a living document and part of a continuous management process. The CRAP should be reviewed and updated periodically as described by the catchment management planning guidelines under the results-based monitoring and evaluation activities and at least every five years to harmonise with institutional planning cycles.

1 INTRODUCTION

1.1 Project Background

The Ministry of Water and Environment (MWE) received financing from the Global Environment Facility (GEF) for the development of the “Strengthening the Adaptive Capacity and Resilience of Communities in Uganda's watersheds – Awoja Catchment (SACRiAC)” project. The project is well-aligned with the GEF-7’s LDCF1 programming strategy and Uganda’s National Adaptation Programme of Action (NAPA) and National Development Plan (NDP). It aims to strengthen resilience of approximately half a million vulnerable people in the Awoja Catchment to the impacts of climate change, through adaptation technology transfer (strategic objective 1) and climate mainstreaming (strategic objective 2). The project is supporting integrated adaptation planning at watershed level, strengthening resilience of critical rural infrastructure, including riverbanks and wetlands, in order to support sustainable agriculture and alternative livelihoods; as well as enhancing access to reliable climate and weather information for climate change integration in development programmes. The project is being implemented through joint collaborative efforts from Ministry of Water and Environment’s deconcentrated structures to contribute towards addressing the critical challenges related to development of resilient water and sanitation infrastructures, natural resources management and sustainable socio-economic development.

Key to this project is Component 2: Strengthened capacity of communities and institutions for climate resilient planning in four watersheds. The infrastructure investments will be accompanied by various capacity building measures. It is planned that 1 watershed level and 9 (3 per watershed) micro-catchment level climate resilient plans will be developed.

A part of the funding from the Global Environment Facility (GEF) is to be used for the “Preparation of the Climate Resilience Action Plans (CRAP) for the Sironko Sub-catchment and nine micro-catchments of Upper Muyembe, Sirimityo, **Lower Muyembe**, Sasa, Sisiyi, Lower Simu, Upper Sironko, Middle Sironko and Lower Sironko.” This report presents the CRAP for the Lower Muyembe micro-catchment, and is part of nine others for the different micro-catchments, which have been prepared separately.

1.2 Objective and purpose of the CRAP

The overall objective of the consultancy was to develop an elaborate Climate Resilient Action Plan for the Lower Muyembe Micro-catchment, which supports the reversal of catchment degradation, increased ecosystem resilience and productivity, and improved community livelihoods/ socio-economic development.

The development of the Lower Muyembe Micro-catchment CRAP follows the Catchment management planning guidelines developed by the Ministry of Water and Environment in 2014. The schematic diagram in Figure 1-1 outlines the steps followed in development of a Catchment Management Plan including a number of tasks as recommended by the guidelines.

This report specifically describes a series of steps to develop the Lower Muyembe CRAP, which is step two of the guidelines.

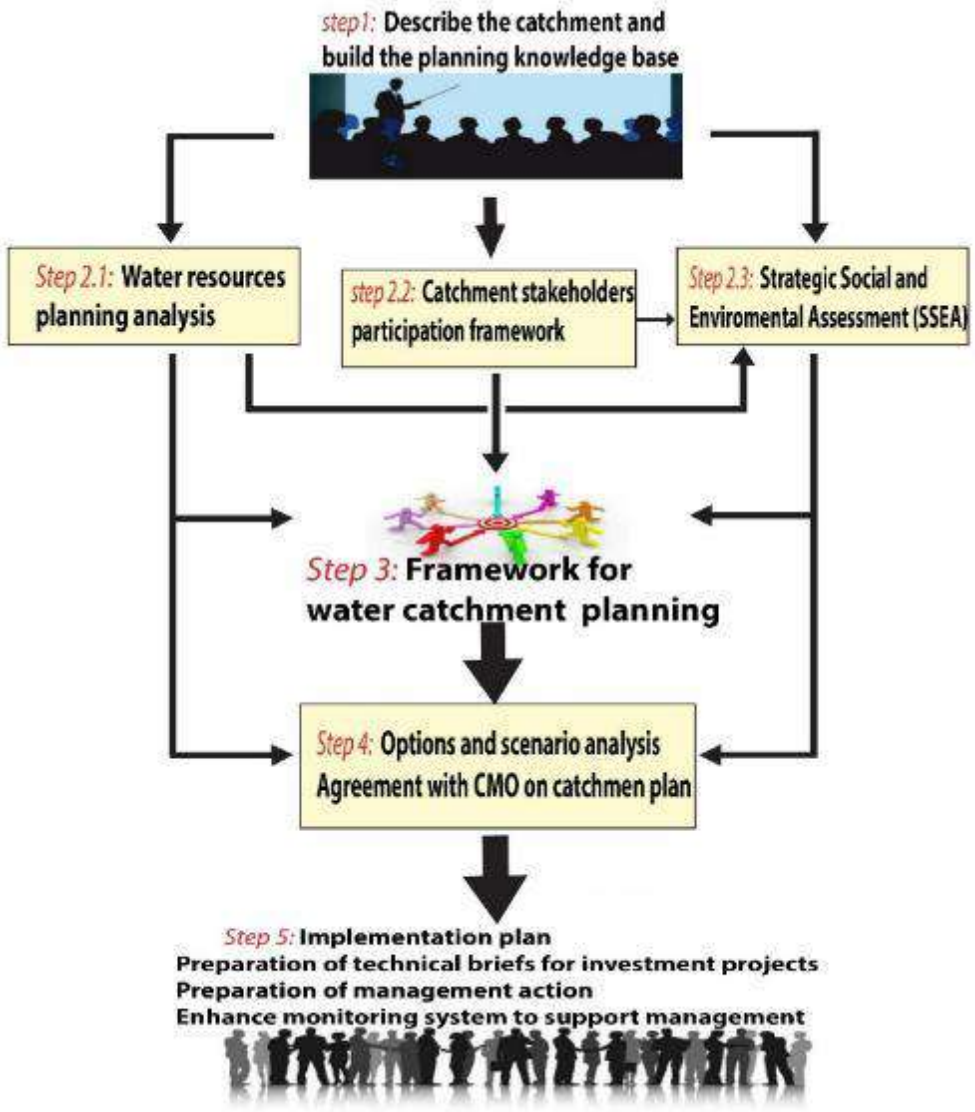


Figure 1-1: Catchment Management Planning process (MWE, 2014)

1.3 Purpose of this CRAP

The purpose of the CRAP is to systematically;

- Consider all conditions and characteristics (physical, social, economic, environmental, political, transboundary) in the Micro-catchment in an integrated manner
- Raise awareness on the understanding and importance of as well as the responsibility for water resources management and environmental conservation among all stakeholders and how this will be of benefit to the sustainable economic growth and livelihoods in the catchment as a learning process
- Clarify the interdependence of all activities in the catchment and even effects on neighboring catchments
- Engage the stakeholders on all levels in the integrated planning process and help them decide on the best options and scenarios for the development of their catchment as well as in the development and implementation processes
- Motivate the stakeholders and put them into the positions to play an active role in preserving their natural resources and the environment

- Provide a basis for evaluation and development of investment options needed first to conserve the Micro-catchment's natural resources and secondly to improve the community livelihoods.

1.4 Report Structure

The report structure has been adopted from the revised catchment management guidelines. It has eight chapters prepared to ensure logical and consistent flow of information throughout the document as highlighted here below:

Table 1-1 Report structure

Chapter 1:	Introduction	▪ The background to catchment management planning in Uganda, ▪ Objectives and purpose of the CRAP, ▪ General structure of the report, and ▪ Policy and legal content
Chapter 2:	Catchment Description and Planning Knowledge Base Building	▪ The natural resource, ▪ People, economic activities, important social aspects, ▪ Present developments and use of water
Chapter 3:	SSEA	▪ Strategic social and environmental issues, vulnerabilities and threats in the catchment ▪ Potential mitigation measures, how should these issues be addressed in formulating the catchment
Chapter 4:	Water Resource Assessment	▪ Rainfall, evaporation, runoff and stream flow ▪ Groundwater – occurrence, recharge characteristics ▪ Floods risks, historical occurrence and impacts
Chapter 5:	Water Demand and Water Balance	▪ Present water use and infrastructure ▪ Projections of future water demand ▪ Water balance - issues
Chapter 6:	Alternative Catchment Scenarios	▪ Presents planning objectives ▪ Options o Modification of existing water infrastructure and water use o Investment in new infrastructure, rehabilitation of existing infrastructure o Mitigation of adverse impact of development o Catchment protection and water conservation o Water management options operating rules ▪ Scenarios Analysis ▪ Multi-criteria evaluation
Chapter 7:	The Consensus Catchment Plans	▪ List of identified, confirmed and quantified priority catchment management investments ▪ Pre-Feasibility reports and costed plans for identified priority investments
Chapter 8:	Implementation Plan	▪ General Prioritization of Interventions ▪ Roles and Responsibilities ▪ Investment and Management Actions ▪ Financing Sources

1.5 Institutional and Legal Assessment

1.5.1 Rationale and objectives

The objective of this task was to assess the existing institutional constraints and opportunities for efficient management of the Micro-catchment. Based on this assessment, then the task was to design the institutional arrangement for implementation of the planned Lower Muyembe Climate Resilient Climate Action Plan (CRAP).

The approach used included:

i. Reviewing the existing legal, policy and regulatory frameworks governing water resources management
ii. Assessment of the institutional structures and capacities relevant for the CRAP implementation at all levels (international, national, regional and local).

During the process, the relevance of the existing policies and institutional arrangements as regards to catchment management was assessed.

1.5.2 Policy and legal framework

The Africa Water Vision 2025 states its goal as “an Africa where there is an equitable and sustainable use and management of water resources for poverty alleviation, socio-economic development, regional cooperation, and the environment” and the water policy reform initiative is aimed at realising this vision for water management in Uganda within the IWRM framework. Worth noting is the fact that sustainable management of water resources is not limited to physical management but also incorporates legislation, policies, economic tools, institutions, and stakeholders involved in management, regulation, and utilisation of water resources. Whilst water is essential to livelihoods, and always provides for subsistence and survival, it does not solely drive economic development. Many other factors also have to be in place if the provision of water is to have its full beneficial impact on society. A strong cooperative approach between role-players and especially governmental institutions is, therefore, essential to work together within their respective legislative and policy mandates to promote the approach to IWRM and to ensure the best economic, social and environmental development.

A synopsis of the legal context in Uganda under which IWRM is implemented and managed is provided by:

i) The Constitution of the Republic of Uganda
ii) National Policies
iii) National Legislation
iv) Trans-boundary considerations, and
v) International Convention

The relevance of the above highlighted legal and policy aspects has been summarised below.
A synopsis of the legal context in Uganda under which IWRM is implemented and managed is provided by:

vi) The Constitution of the Republic of Uganda
vii) National Policies
viii) National Legislation

ix) Trans-boundary considerations, and
x) International Convention
xi) Third National Development plan of 2020/21 – 2024/25

The relevance of the above highlighted legal and policy aspects has been summarised below.

1.5.3 Constitution of the Republic of Uganda, 1995

The constitution guides all the enacted relevant Uganda's laws, policies, regulations, guidelines, institutional framework and plans applicable to Water resources management. Through the constitution, the State is entrusted to protect important natural resources including land, water, wetlands, minerals, oil, and fauna and flora on behalf of the people of Uganda. The Constitution further stipulates that all Ugandans have a right to education, health services, clean and safe water, work, decent shelter, adequate clothing, food security, and pension and retirement benefits. The State must promote sustainable development and public awareness of the need to manage land, air, water resources, as well as use of natural resources, in a balanced and sustainable manner for the present and future generations. All possible measures must be taken to prevent or minimise damage to land, air, and water resources resulting from pollution or other causes. The Constitution entrusts the State to ensure the conservation of natural resources and promote the rational use of natural resources to safeguard and protect the biodiversity of Uganda. Through all this, the Constitution sets the scene for Integrated Water Resource Management in Uganda.

1.5.4 National Policies

a) National Water Policy, 1999

The 1999 National Water Policy provides an overall policy framework that defines the Government's policy objective as managing and developing water resources of Uganda in an integrated and sustainable manner, to secure and provide water of adequate quantity and quality for all social and economic needs sustainably, with the full participation of all stakeholders (MWE, 2012).

According to the National Water Policy and the Water Act Cap 152, the responsibilities to provide water services and to maintain facilities were devolved to local councils in districts and urban centres. The role of the Central Government's Agencies is that of guiding and supporting as required. The Act thus emphasises the shared responsibilities in development and management of water resources among stakeholders, including the Private Sector and non-Government organisations (NGOs) to regulate human activities that can pose risks to water resources. It also provides for pollution control measures with associated penalties and fines.

The existing policy and legal framework promote wise use of water resources from the lowest possible level, while considering roles to be played by different stakeholders at different levels. This offers an opportunity to ensure that communities can actively participate in the development and maintenance of water sources within a given catchment.

The development of the climate resilience action plans is in line with the National Water Policy that ensures integrated water resources management at a catchment level. This policy is currently under review with the draft policy having been published in 2018.

b) National Policy for the Conservation and Management of Wetland Resources, 1995

The sustainable use and conservation of wetlands in Muyembe, Sironko and Simu Sisi catchment requires a coordinated and cooperative approach involving stakeholders at different levels. This policy defines the guiding principle goals of; wetland optimal use, maintenance of biological diversity and wetland functions and values, and integration of wetland concerns into the planning and decision making of other sectors. The plan will seek to ensure that benefits derived from the catchment are sustainably and equitably utilized on environmental sound grounds as to restrict the continued loss of wetlands and their associated resources.

The wetlands policy calls for:

- No drainage of wetlands unless more important environmental management requirements supersede;
- Sustainable use to ensure that benefits of wetlands are maintained for the foreseeable future;
- Environmentally sound management of wetlands to ensure that other aspects of the environment are not adversely affected;
- Equitable distribution of wetland benefits; and
- The application of environmental impact assessment procedures on all activities to be carried out in a wetland to ensure that wetland development is well planned and managed.

Wetland related issues have been incorporated into the National Environmental Act 2019.

Within the context of the guiding principles, the National Wetlands Policy sets five goals:

a) To establish the principles by which wetland resources can be optimally used over time;
b) To end practices, which reduce wetland productivity;
c) To maintain the biological diversity of natural or semi-natural wetlands;
d) To maintain wetland functions and values; and
e) To integrate wetland concerns into the planning and decision making of other sectors.

c) The Uganda National Land Policy, 2013

The Uganda National Land policy provides a framework for articulating the role of land in national development, land ownership, distribution, utilization, alienability, management, and control of land. The Land Policy has a specific objective that seeks to ensure sustainable utilization, protection and management of environmental, natural and cultural resources on land for national socio-economic development. It seeks to ensure that all land use practices and plans conform to principles of sound environmental management, including biodiversity, preservation, soil and water conservation, and sustainable land management. Section 6.7, item 140 of the policy promotes optimal and sustainable use and management of environment and natural resources for the present and future generations.

The policy therefore provides a framework for strategic management of environmentally sensitive areas such as Sironko river, groundwater, natural streams, wetlands, forest reserves, national parks and other land reserved for ecological purposes as delineated in the catchment.

d) National Environment Management Policy for Uganda, 1994

The key objectives of the National Environment Management Policy are to manage and develop the water resources in a coordinated and integrated manner so as to provide water of acceptable quality for all social and economic needs and to control pollution of water from industrial and other emissions and discharges and promote environmentally sound management of wastes and hazardous materials. The policy has been a guiding yardstick for development of the Strategic Social and Environment Assessment (SSEA) for Lower Muyembe Micro-catchment planning, including control of pollution of water, use of rivers systems, protection and management of river banks and wetland systems, Hilly and mountainous areas and investment plan/ interventions.

e) The Uganda Forestry Policy, 2001

The National Forestry policy provides for the establishment, rehabilitation and conservation of watershed protection forests. It aims at promoting the rehabilitation and conservation of forests that protect the soil and water in Uganda's key watersheds and river systems. In relation to the development of CRAP, the policy therefore emphasises the need to adopt appropriate; private, community and farm tree planting initiatives, development of guidelines on the management of riverside forests and promote awareness, educational and community mobilisation programmes to promote good integrated land use practices in hilly areas.

f) Uganda Wildlife Policy, 2014

This Policy provides a framework within which all Government institutions, private sector, development partners, civil society and all other stakeholders in the wildlife conservation industry must operate in order to sustainably conserve and develop the wildlife resource base for national social-economic transformation. Additionally, it promotes climate change awareness, mitigation and adaptation pursuing initiatives that build capacity of wildlife populations and people to be more resilient to climate change shocks.

The policy therefore promotes climate change initiatives and conservation of the wildlife population in Mountain Elgon National Park and protected areas in the project area.

g) Uganda National Climate Change Policy, 2012

In response to support of ongoing efforts to ensure that climate change concerns are integrated into national efforts for sustainable and long-term conservation, access and effective utilization and management of water resources, the policy calls for promotion and strengthening the conservation and protection against degradation of Sironko water catchment areas and river banks under Integrated Water Resources Management including contingency planning for extreme events such as floods and trans-boundary cooperation.

h) National Irrigation Policy, 2017

MWE in support of utilization of best practices to minimize unsustainable exploitation of water resources using an IWRM approach to irrigation planning, development and management is undertaking comprehensive climate resilience action plan with full participation of all stakeholders in line with this policy. The plan will promote irrigated agriculture and water allocation based on economic, social and environment values of water with integration of the stakeholders with in the catchment. The policy recognizes Ministry of Agriculture, Animal Industry and Fisheries (MAAIF) as a major stakeholder.

i) National Agricultural Policy, 2013 and the National Agriculture Extension Policy 2016

The overall objective of agricultural policies is to achieve food and nutrition security and improve household incomes through coordinated interventions that focus on enhancing sustainable agricultural productivity. The policy guides on developing plans that will promote strategic, profitable and sustainable use and management of agricultural resources; through employing and training farmers in better methods of farming in order to develop human resources for agricultural development and increase households' incomes in the project area.

j) National Gender Policy, 2007

Crop farming is the main activity practised throughout the catchment area, mainly dominated by women input. Stakeholder planning involved gender inclusions that prompted gender analysis in macro-economic programmes for intervention as to ensure strengthen women's presence and capacities indecision making. The policy therefore recognises women and children in the project area as the key stakeholders of water. The policy guided the identification of catchment management interventions designed to achieve gender equality and women's empowerment. The same policy defines Ministry of Gender, Labour and Social Development (MGLSD) as a major catchment planning stakeholder specifically Gender Department.

k) National Fisheries and Aquaculture Policy, 2017

As part of the business support system and alternative livelihoods in the project area, this policy encourages fish farming and supporting of structures for training interested farmers will be put in place. This will attract investment and transform current farmers in the catchment from subsistence to profit oriented commercial producers through cost effective methods, technologies, and business management skills.

National legislations and regulations

a) The Water Act, Cap. 152. 1997

Uganda's Water Act Cap 152 provides for the use, protection and management of water resources and supply; and facilitates the devolution of water supply and sewerage undertakings. Its objectives are:

i) To promote the rational management and use of the water resources of Uganda by;
   - Use of appropriate standards and techniques for the investigation, use, control, protection, management and administration of water resources.
   - Coordinating all public and private activities which may influence the quality, quantity, distribution, use or management of water resources.
   - Coordinating, allocating and delegating responsibilities for the investigation, use, control, protection, management or administration of water resources.

ii) To promote the provision of a clean, safe and sufficient supply of water for domestic purposes.

iii) To ensure appropriate development and use of water resources other than for domestic use, e.g. watering of stock, irrigation and agriculture, industrial, commercial and mining uses, generation of energy, navigation, fishing, preservation of flora and

fauna and recreation in ways which minimise damage to the environment; and

iv) To control pollution and promote the safe storage, treatment, discharge and disposal of waste, which may pollute water or otherwise harm the environment and human health.

According to the National Water Policy (1999) and the Water Act Cap 152, 1995 the responsibilities to provide water services and to maintain facilities are devolved to local councils in districts and urban centres, with full mandates to construct, acquire or alter any water supply work. The role of the Central Government's Agencies is that of guiding and supporting as required. The Act thus emphasises the shared responsibilities in development and management of water resources in project area catchment among stakeholders (including the Private Sector and NGOs) to regulate human activities that can pose risks to water resources. It also provides for pollution control measures with associated penalties and fines.

b) The Water (Waste Discharge) Regulations, 1998

Water (Waste Discharge) Regulations, 1998 specifically controls water abstraction and wastewater discharge, to promote sustainable and environmentally friendly development and use of water resources.

The regulation will be benchmarked as per waste discharge permit requirements in schedule 1 and 4 during project area catchment management planning.

c) The National Environmental Act, Cap. 153, 2019

The National Environmental Act (2019) provides for *"sustainable management of the environment; to establish an authority as a coordinating, monitoring, and supervisory body for that purpose; and for other matters incidental to or connected with the foregoing*."

The Act makes provision for a tiered approach to environmental planning, commencing with a National Environmental Management Plan to be prepared and reviewed every five years. Each district is required to compile a district environmental action plan every three years that compliments the National Environ- mental Management Plan. Both of these plans are made available to the public. At a project scale, the Act stipulates that developments of a certain nature (as determined under Section 19(7) of the Act) are required to undertake detailed Environmental Impact Assessment process in a prescribed manner.

The Act also makes provision for the monitoring of air and water quality and makes provision for the establishment and implementation of minimum standards on emissions and effluent.

Section 34 of the Act deals specifically with limitations in the use of rivers and lake systems and aims to minimise the negative impacts and control activities that have the potential to be detrimental to these systems. The Act goes on to make specific provisions for the protection of river banks and lake shores in Section 35 and protection and management of wetland systems in Section 36 and 37 respectively.

Hilly and mountainous areas have also been identified as areas requiring special attention and protection by the Act. The Act makes provision for the restoration of vegetative cover in these areas. This Act coupled with the provisions made in the Prohibition of the Burning of Grass Act (1974) and the Forest Act (1947) and the Cattle Grazing Act (1945) provides a good basis for restoration, protection and management of vegetative cover in hilly and mountainous areas.

Other policies which form synergies with the Water Policy and legislation are:

d) The Local Governments Act, Cap. 243, 1997 (As Amended, 2015)

The Local Governments Act 1997 (Cap. 243) (Amended 2015), underscores the role of Local Government in provision and management of water and sanitation, empowering the local authorities to plan and implement development interventions according to local needs.

With regard to the management of the sub/micro-catchment, Bulambuli, Kapchorwa and Sironko District Local Government is the key stakeholder through democratic participation in, and control of, decision making as per this Act. It underscores provision and management of water and sanitation, empowering the local authorities (sub-counties, Divisions, Town councils and villages) to plan and implement development and management interventions according to local needs and environment of the project area.

e) The Land Act, Cap. 227 and Land (Amendment) Act, 2010.

The Land Act 1998 (Cap. 227) stipulates the responsibility of the Central and Local Government in protecting environmentally sensitive areas such as natural lakes, rivers, groundwater, natural ponds, natural streams, wetlands, forest reserves, national parks and any other land reserved for ecological and tourist purposes.

Its amendment in 2010 further emphasises the need to enhance the security of occupancy of lawful and bona fide occupants on registered land in the sub/micro-catchment.

f) Historical Monuments Act, Cap 46, 1968; Historical Monuments (Declaration of Protected Objects) (Constitution Square) Instrument, 2007

Bamasaba Kingdom, in which the catchment is delineated, bears many historical archaeological, paleontological, and ethnographical objects. Any of such findings identified or recovered during the proposed catchment management interventions implementation stage will be handled and managed as provided by this Act. The Act defines Ministry of Tourism wildlife and antiquities (MTWA) specifically Department of Museum and Monuments as a major stakeholder for catchment planning.

g) National Forestry and Tree Planting Act, 2016

The Act safeguards the environment benefits that accrue from forests and trees by ensuring that forests and trees are conserved and managed in a manner that meets the needs of the present generation without compromising the rights of the future generations by safeguarding

h) Uganda Wildlife Act, Cap 200. 2019

The Act provides for sustainable management and conservation of wildlife; to consolidate the law relating to wildlife management; to assist in water catchment conservation; to establish a coordinating, monitoring and supervisory body. For this purpose, the Uganda Wild Life Authority streamlines the roles and responsibilities of the institutions involved.

The Act therefore provides for promotion of the activities of the Uganda Wild Life Authority in the catchment and to increase wildlife population in Mountain Elgon National Park and, protected areas in the catchment.

i) The Fish Act Cap. 197, 2011, The Fishing Rules, 2010

The Act regulates and provides for fish farming including support structures for training interested fish farmers. The Act also regulates activities that can become potential risks to

aquaculture such as increased water pollution.

j) National Environment (Noise Standards and Control) Regulations, 2003

The regulation provides for inclusion of noise monitoring indictors as per schedule 1 to 12, in the proposed CRAP catchment management interventions.

k) National Environment (Waste Management) Regulations, 1999

The regulation provides for inclusion of waste management strategies in the proposed CRAP as per SSEA.

l) National Environment (Mountainous and Hilly Areas Management) Regulations, 2000

River Sironko sub-catchment and the nine micro-catchments are located in the mountainous areas, which are part of the Elgon Mountain. The catchment management plan will follow the regulations to guide in the sustainable utilization and conservation of resources in mountainous and hilly areas by and for the benefit of the people and communities living in the area. All interventions suggested will be guided by these regulations.

m) Draft National Air Quality Standards, 2006

The regulation will guide inclusion of air monitoring indictors in the proposed Sironko sub-catchment and the 09 micro- catchment management interventions.

n) Uganda Vision 2040

Lower Muyembe CRAP will contribute towards the improvement of water security and mitigate ad- verse effects of floods and droughts, large and strategic water reservoirs will be constructed and maintained in appropriate areas within the catchment. Vision 2040 aims at ensuring optimal and sustainable utilisation of the water resources where Government will strengthen and manage water resources at the lowest appropriate levels. This will be at water management zones and water catchment zones.

1.5.5 The institutional context

1.5.5.1 National Level

a) The Ministry of Water and Environment (MWE)

The Ministry of Water and Environment (MWE) plans and coordinates all water and environmental sector activities and is the ultimate authority responsible for water resources and environmental management in Uganda. The MWE has the overall responsibility for setting national policies and standards related to water and the environment, managing and regulating all water resources and determining priorities for water development and management. The MWE is divided into three directorates: Directorate of Water Resource Management (DWRM), the Directorate of Water Development (DWD), and the Directorate of Environmental Affairs (DEA).

The DWRM is responsible for managing and developing water resources of Uganda in an integrated and sustainable manner in order to provide water of adequate quantity and quality for all social and economic needs for the present and future generations. The Directorate comprises of four departments namely: Water Resources Monitoring and Assessment Department, Water Resources Planning and Regulation Department, Water Quality

Management Department and the International Trans boundary and Water Affairs Department.

The DWD has the responsibility for providing overall technical oversight for the planning, implementation, and supervision of the delivery of urban and rural water and sanitation services across the country including water for production. It is responsible for regulating the provision of water supply and sanitation and the provision of capacity development and other support services to Local Governments, Private Operators and other service providers. The Directorate comprises of three Departments: Rural Water Supply and Sanitation, Urban Water Supply and Sanitation, and Water for Production.

The DEA is responsible for environmental policy, regulation, coordination, inspection, supervision and monitoring of the environment and natural resources as well as the restoration of degraded ecosystems and mitigating and adapting to climate change. The DEA comprises of four departments namely: Department of Environmental Support Services (DESS), Forestry Sector Support Department (FSSD), Wetlands Management (WMD), and the Department of Meteorology (DOM), recently turned into an Authority.

MWE further works closely with the National Environment Management Authority (NEMA), which is man- dated with the coordination, monitoring, regulation, and supervision of environmental management; the National Water and Sewerage Corporation (NWSC) — with the mandate to operate and provide water and sewerage services in the larger urban centres; and the National Forest Authority (NFA), whose mandate is to manage Central Forest Reserves and to supply high quality forestry-related products and services (

Figure 1-2). The MWE works hand in hand with other national entities as described below, which are directly or indirectly affected by water management issues.

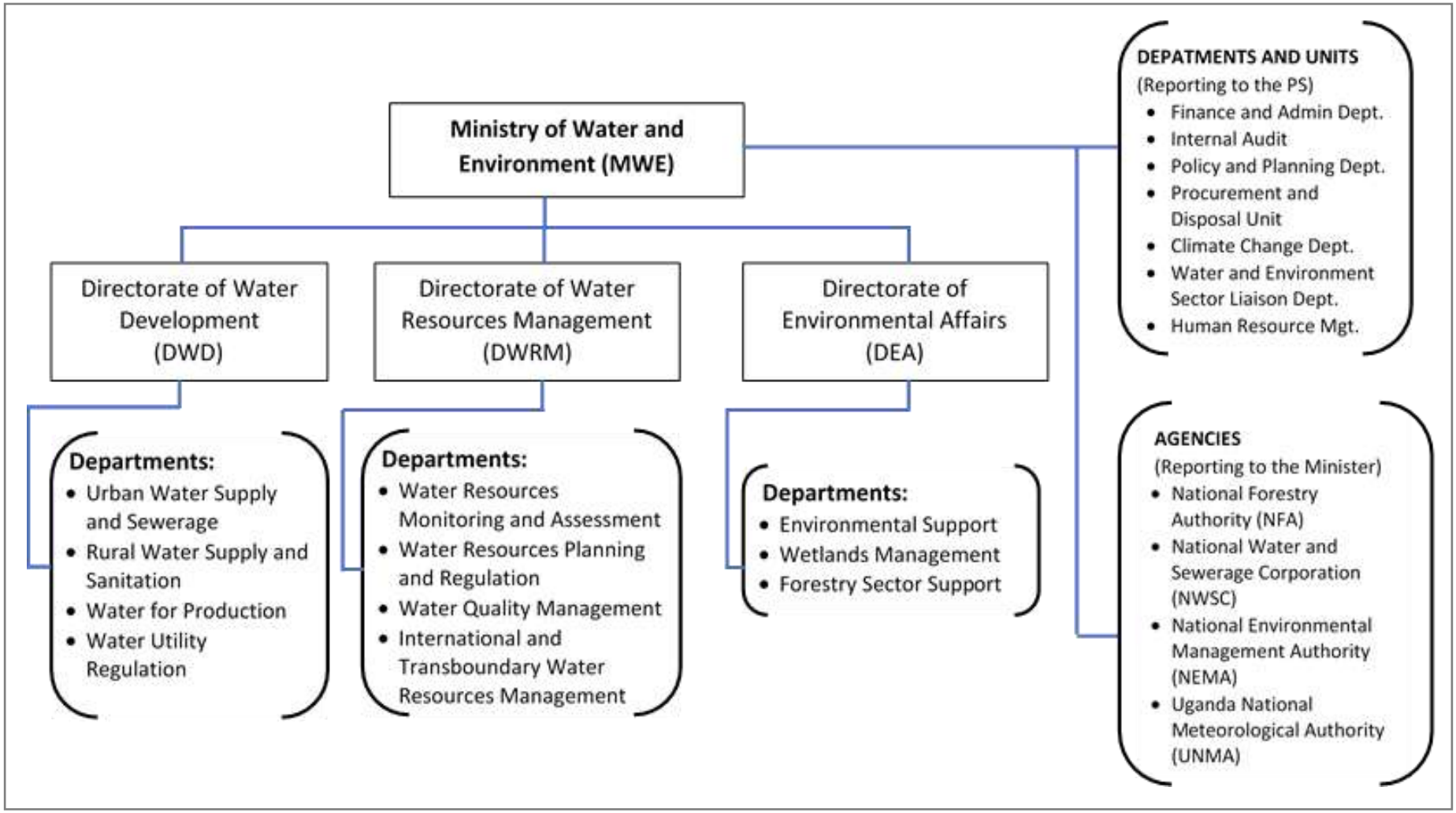


Figure 1-2: Organogram of the institutional set-up at a national level (MWE, 2009)

b) Ministry of Agriculture, Animal Industry and Fisheries (MAAIF)

MAAIF is a government ministry responsible for creating an enabling environment in the Agricultural Sector. It is commonly known as Ministry of Agriculture and carries out its role by enhancing crop production, improving food and nutrition security, widening export base and improved incomes of the farmers. MAAIF is mandated to: formulate, review and implement national policies, plans, strategies, regulations and standards and enforce laws, regulations and standards along the value chain of crops, livestock and fisheries; control and manage epidemics and disasters, and support the control of sporadic and endemic diseases, pests and vectors; regulate the use of agricultural chemicals, veterinary drugs, biological, planting and stocking materials as well as other inputs; support the development of infrastructure and use of water for agricultural production along livestock, crop and fisheries value chains; establish sustainable systems to collect, process, maintain and disseminate agricultural statistics and information; support provision of planting and stocking materials and other inputs to increase production and commercialization of agriculture for food security and household income; develop public infrastructure to support production, quality/safety assurance and value-addition along the livestock, crop and fisheries commodity chains; monitor, inspect, evaluate and harmonize activities in the agricultural sector including local governments; strengthen human and institutional capacity and mobilize financial and technical resources for delivery of agricultural services; and develop and promote collaborative mechanisms nationally, regionally and internationally on issues pertaining to the sector.

c) The Ministry of Tourism Wildlife and Antiquities (MTWA)

The responsibility of the Ministry of Tourism, Wildlife and Antiquities is to sustain tourism, wildlife and cultural heritage. This is aimed at contributing to transforming Uganda into a prosperous country. The Ministry has a mission to develop and promote the tourism, wildlife and heritage resources for enhancement of Uganda as a competitive and preferred tourist destination, with accelerated sector contribution to the national economy. The MTWA is mandated to: formulate, implement policies of Tourism, Wildlife and Cultural heritage; sustain and manage wildlife and cultural heritage conservation areas; diversify Tourism Product; promote and market Uganda as a preferred tourism destination; develop human resource capacity in Tourism, Wildlife and Heritage sector; regulate and Quality Assure Tourism, Wildlife and Heritage programs and services; disseminate and manage Tourism, Wildlife and Heritage Research, information; and negotiate, conclude and implement bilateral and multilateral agreements on Tourism, Wildlife and Heritage in Uganda.

Uganda Wildlife Authority (UWA) is a statutory body established by the Uganda Wildlife Act 2000 mandated with:

1) Management and conservation of wildlife in Uganda, both in and outside the wildlife protected areas (PAs) i.e. National Parks, Wildlife Reserves and Wildlife Sanctuaries.

2) Promoting public participation in wildlife management using mechanism such as wildlife use rights, as a means of eradicating poverty, through community conservation programs, and promoting wildlife as a form of land use.

3) Ensuring the protection of rare, endangered and endemic species of wild plants and animals, through provision of appropriate wildlife policies, management plans and promotion of wildlife management best practices.

4) Ensuring timely and appropriate response to reported problem animals, in collaboration with the concerned communities and respective local authorities.

5) Enhancing economic benefits from wildlife management through promotion of tourism and

6) Implementation of relevant international treaties, conventions, agreements or other arrangements to which Uganda is a party.

d) Ministry of Energy and Mineral Development (MEMD)

MEMD is a government ministry to manage utilization of energy and mineral resources for development of Uganda and its people. The Ministry is concerned with matters such as energy policy, investments in mining, the establishment of new power generating infrastructure using hydro power, thermal power, solar power and nuclear power. MEMD is mandated to: provide policy guidance in the development and exploitation of the energy and mineral resources; create an enabling environment in order to attract investment in the development, provision and utilization of energy and mineral resources; acquire, process and interpret technical data in order to establish the energy and mineral resource potential of the country; and inspect, regulate, monitor and evaluate activities of private companies in energy and mineral sectors so that the resources are developed, exploited and used on a rational and sustainable basis.

e) Ministry of Trade, Industry and Cooperatives (MTIC)

MTIC is responsible for promoting trade and industry and cooperatives for the development of the country. This Ministry is to ensure expansion and diversification of trade, cooperatives, environmentally sustainable industrialization, appropriate technology, conservation and preservation of other tradable national products. MTIC has the following departments: External Trade, Internal Trade, Cooperative Development, Industry and Technology, Finance and Administration.

f) Ministry of Lands, Housing and Urban Development (MLHUD)

MLHUD is responsible for all matters concerning lands, housing and urban development. The ministry is also tasked to put in place policies and initiate laws responsible for sustainable land management aimed at promoting sustainable housing for all and fostering orderly urban development in the country. The Ministry Directorates include: Lands; Physical Planning and Urban Development; and Directorate of Housing.

g) The Ministry of Health (MOH)

Ministry of Health is responsible for one of the important sectors that takes care of promoting a healthy and productive life for the population in Uganda. This Ministry aims to have the highest possible level of health services to all people in Uganda. This is approached by overseeing health services delivery, promotion, and prevention, curative, palliative and rehabilitative services at all levels. MOH is engaged in the monitoring and provision of clinical support functions, regulatory functions and research activities related to health.

h) The Ministry of Local Government (MoLG)

The MoLG oversees the implementation of Local Government Development Plans, which include water supply and programmes for the improvement of hygiene and sanitation in institutions and public places.

There are a number of development partners, private sector, and NGOs that also act in the water sector providing services, advice, and facilitation. A number of NGOs active in the water sector are coordinated at the national level through the Uganda Water and Sanitation NGO Network (UWASNET), an umbrella organisation largely funded by development partners and the MWE. An outline of organisations directly or indirectly involved in water management is indicated in Figure 1-4.

Coordination is a key process for Integrated Water Resources Management (IWRM), which involves multiple stakeholders from different sectors, on different scales, and with different structures and interests. At the national level, the following committees are relevant to integrated water resources management:

The Policy Committee on Environment: chaired by the Prime Minister, at the highest level of political decision-making.

- The Water Policy Committee, which is composed of directors, and enables high-level and strategic dialogue specifically in the water sector.
- The IWRM Working group, which is an informal working group enabling technicians to coordinate.
- The Water and Environment Sector Working Group (WESWG).
- The Inter-Ministerial Technical Committee regarding Water for Production, comprising members from the MWE, Ministry of Agriculture, Animal Industry and Fisheries (MAAIF), Office of the Prime Minister, National Planning Authority, and Ministry of Finance. It meets on a quarterly basis to co- ordinate investments and works regarding water for production.
- The Wetlands Advisory Group (WAG), which is a technical group dedicated to wetlands. The WAG improves coordination on wetlands issues, particularly on the issue of dry land rice
- The MWE-DWRM has created Water Net, a network for building capacities of stakeholder's connected to the water sector

The National Environment Management Authority (NEMA) is the apex body for environmental law enforcement in Uganda. However, several functions have been delegated to other institutions as lead agencies in their respective fields. NEMA is in charge of:

- Review and administrative clearance of environmental evaluations, in conjunction with other lead agencies.
- Delivery of permits (for instance, permits for activities within the legal buffer zones of water bodies).
- The responsibility of delivering permits is vested into the different lead institutions.
- Monitoring compliance. The responsibility of control is distributed over 375 gazetted inspectors (2014) distributed in many Ugandan institutions (including the MWE). Only 30 of them belong to NEMA.

An Environmental Police has been formed at NEMA, comprising 25 officers. Only five regional Environ- mental Police officers (liaison officers) have been designated, among which one is based in Mbale (for the eastern region: his area covers 52 districts corresponding to a quarter of the country) and one in Jinja (for the south-eastern region). The liaison officers belong to the regular police but are specifically trained in environmental issues. They are under the command of the territorial police (Regional Police Commander/District Police Commander). Their functions include sensitisation,

demarcation, and control, issuing warnings, following up of cases, eviction, and prosecution.

Within each district, there are offices that are in charge of the environment, forestry, wetlands, agriculture, fisheries, planning among others. However, the structure varies from district to district.

1.5.5.2 Regional Level

The framework for catchment-based Water Resources Management (CbWRM) which was fully rolled out to the entire country in 2011 led to creation of four Water Management Zones (WMZ) which form part of the de-concentrated regional institutions Figure 1-3. These include; Victoria, Kyoga, Albert and Upper Nile which were delineated based on major hydrological basins in the country.

They operate on regional level with the objective to bring the central services closer to the stakeholders. Their primary role is to facilitate sustainable development of the water resources for the economic and social benefit of the people in the catchment and to implement the water management measures needed to protect and conserve the catchment and its water resources, ensure sustainability, and reduce or resolve conflicts over resource use.

The DWD also established the Water and Sanitation Development Facility (WSDF) as a mechanism for sup- porting water supply and sanitation facilities for rural growth centres and small towns, intended to promote a demand-responsive approach where Water Authorities/Town Councils or Town Boards apply for funding. The successful applicant is assisted by the WSDF to develop piped water supply systems.

Technical Support Units (TSU) established by DWD at the regional level have the mandate to support capacity building of district-based structures. This involves training, technical advice and support supervision of districts to enable them to effectively implement their roles in the rural sub-sector. The mandate also covers water for production.

Umbrella Organizations (UO) are also regional organisations constituted as associations of the local Water Supply and Sanitation Boards (WSSBs) with the principle objective of providing operation and maintenance (O&M) back-up support (training, technical, legal and organisational support, supervision of rehabilitation, and extension works as well as water quality monitoring). The DWD has further deployed staff from its Department of Water for Production to the regions while DEA has also established offices for its Wetlands Department on regional level.

These de-concentrated units in the regions are based together for improved cooperation and integration and represent the MWE on regional level.

1.5.5.3 Catchment Level

During the catchment management planning process, an institutional framework has to be created, which brings the stakeholders together to present and exchange their views and thus give the process legitimacy. Hence, the WMZ establishes Catchment Management Organisations (CMOs), which builds on and utilises to the maximum practicable extent, existing structures and relationships. The CMOs consists of several bodies Figure 1-3:

- **The Catchment Stakeholder Forum (CSF)** brings together all actors on catchment management.

  The CSF defines key issues related to water resources in the catchment that require consideration in order to effectively protect, manage, and develop water resources. It

provides input to the CMP for coordinated, integrated and sustainable development and management of water and related resources in the catchment, including their implementation status.

- **The Catchment Management Committee (CMC)** is composed of representatives of all relevant stakeholder groups (government, politicians, and community-based organisations, NGOs, water users, media, academic institutions, and private sector) and collaborates with the WMZ during the formulation of a Catchment Management Plan and plays a steering role during its implementation. The CMC responsibilities include: coordination of stakeholder-driven definition of key issues related to water resources, promotion of coordinated planning, and implementation as well as stakeholder- driven decision-making related to integrated and sustainable development and management of water and related resources, development of plans for coordinated, integrated and sustainable development and management of water and related resources. It endorses the CMP and presents it to the Catchment Stakeholder Forum for information purposes. The CMC acts as an Executive Board for the Catchment Management Organisation.
- **The Catchment Management Secretariat (CMS)** provides support to the Catchment Management Committee in coordinating the planning and implementation of activities in the catchment as well as following up of recommended actions by the stakeholders. The CMS acts as an administrative secretariat for the Catchment Management Committee as well as the Catchment Technical Committee.

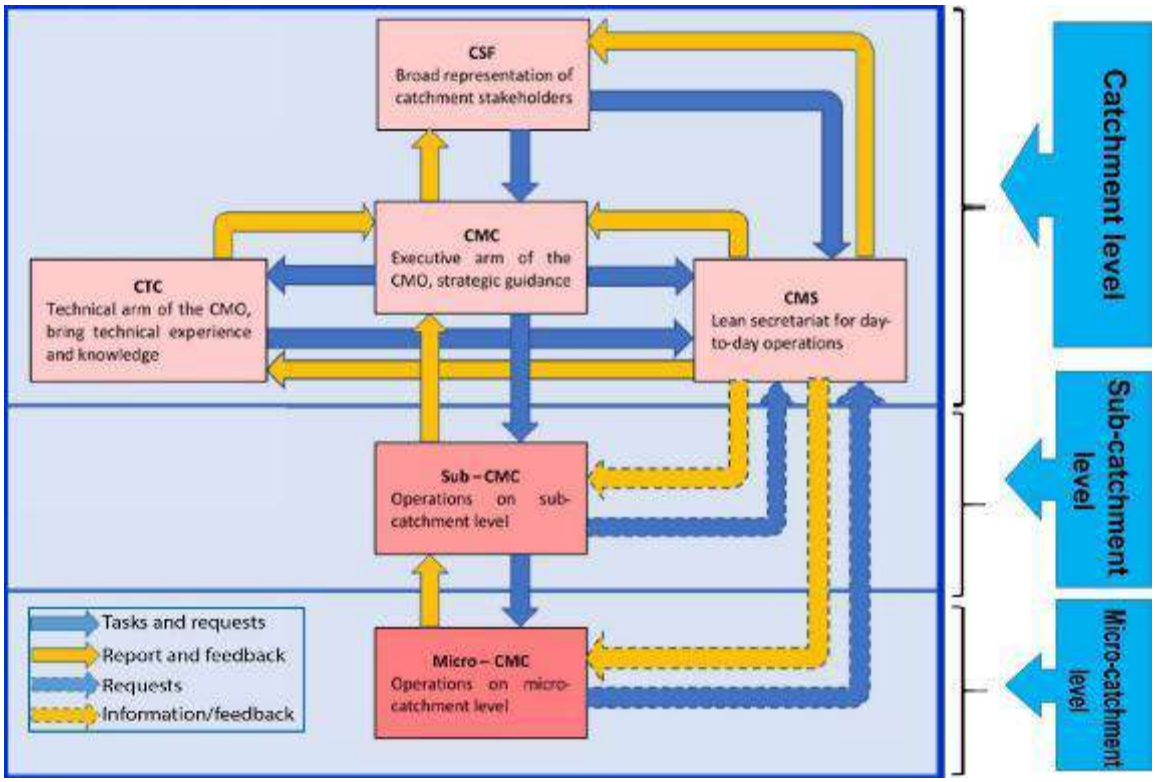


Figure 1-3: Catchment management organisation structure (DWRM, 2016)

- **The Catchment Technical Committee (CTC)** forms the technical arm of the CMO and supports the CMC in their tasks. The CTC brings technical expertise and knowledge during the formulation of the Catchment Management Plan/Climate Resilience Action plans

(CRAP), operationalizes and sometimes implements programmes and projects from the plan, and generally ensures that the different districts collaborate to implement the plan. It comprises of technical people from government, NGOs, private sector, development agencies, and other relevant organisations in the catchment.

Other relevant institutions at the catchment level are:

- The District Natural Resources Department (including the District Environment Office, District Forestry Office, and District Wetlands Office), District Works or Engineering Department under which the District Water Office falls, District Production Department with the District Agricultural Office, District Veterinary Office and District Fisheries Office, District Planning Department, Department of Community Based Services, District Information Department, and District Health Department are key in the implementation of the CRAP. However, the structure varies from district to district according to the natural conditions in the district.
- Policies at national level are translated into Sector Development Plans, which are implemented at district level under the Decentralization Policy. Most districts have 5-year district development plans in which all sector plans are integrated. Natural Resources Management activities are mandated to be implemented by every district, Sub-counties, CBOs and CSOs, Water User Associations etc.
- Sub-counties
- CBOs and CSOs,
- Water User Associations etc.

Additionally, there are a number of private sector and NGOs, which also act in the water sector providing services, advice and facilitation. They work on catchment and regional level or sometimes combine the two. Many of these NGOs are coordinated at the national level through the Uganda Water and Sanitation NGO Network (UWASNET), an umbrella organisation largely funded by development partners and the MWE.

The institutional interlinkages of the different stakeholders at the different catchment levels in the Water and Environment sector are as presented in Figure 1-4 below.

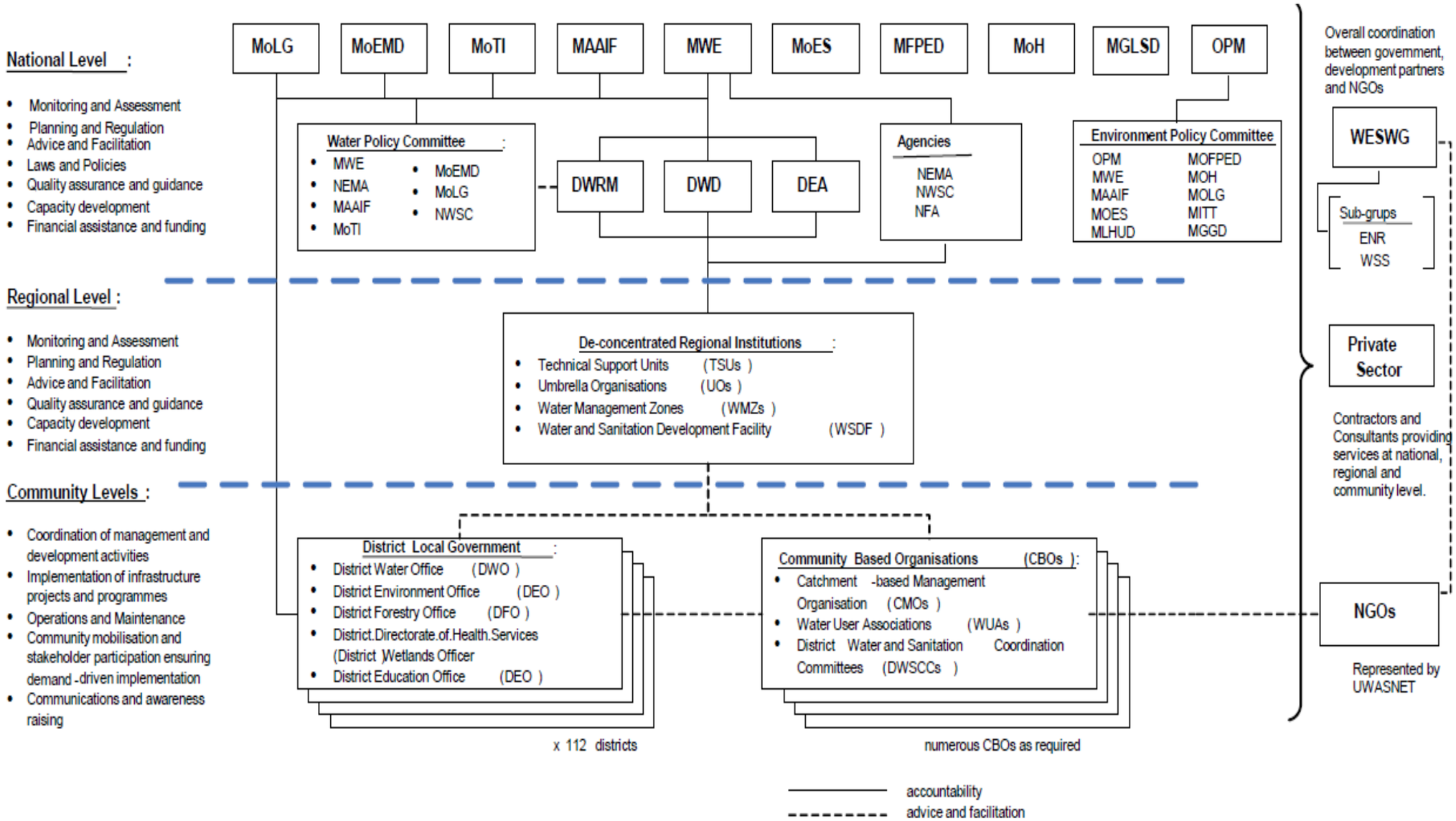


Figure 1-4: Uganda's water and environment sector institutional set-up (MWE, 2009)

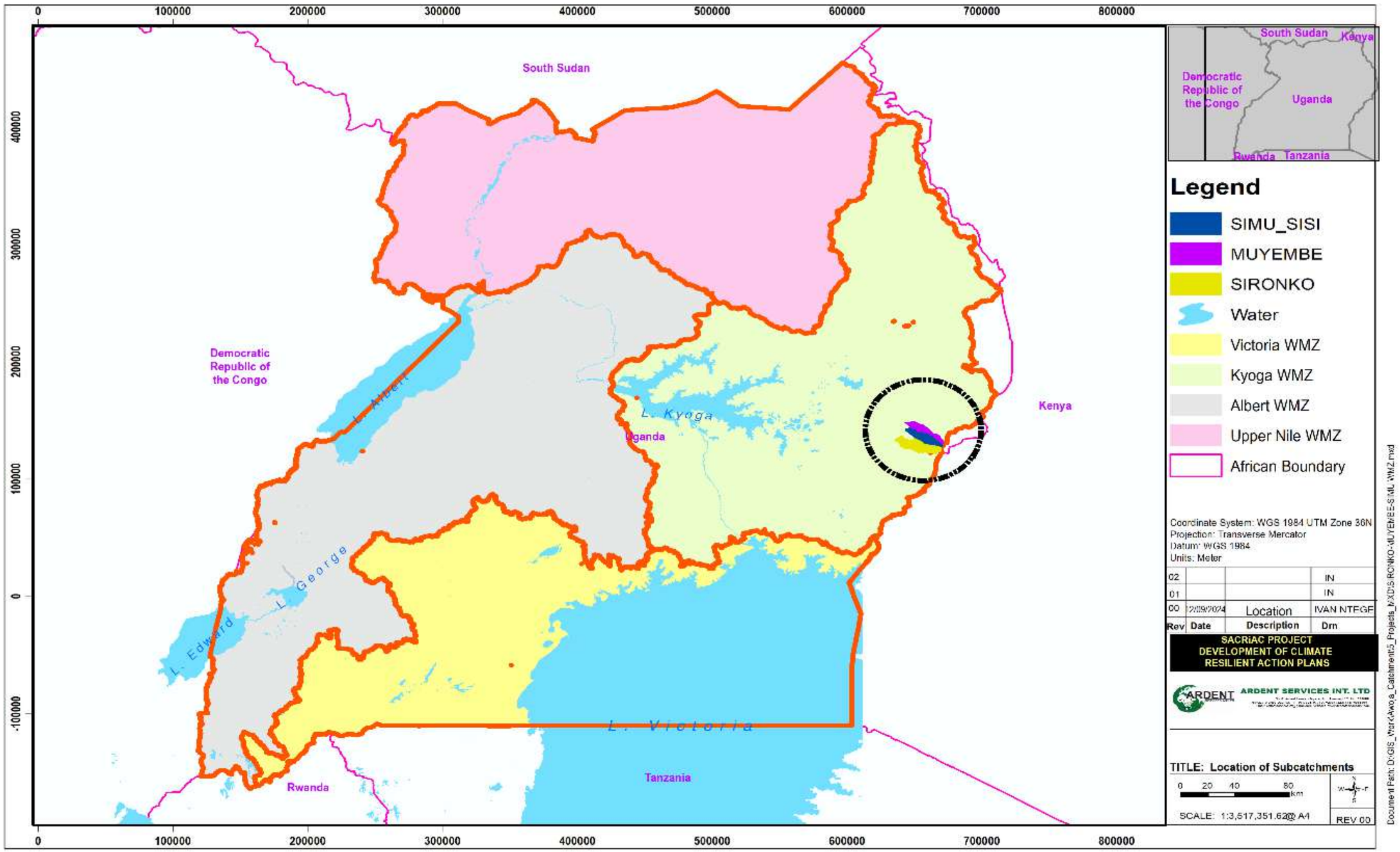


Figure 1-5: Location map of Muyembe sub-catchment within the Kyoga Water Management Zone as one of four water management zones

1.5.5.4 The Kyoga Management Zone and Muyembe sub-catchment

The Kyoga Water Management Zone (KWMZ) catchment area covers approximately 59, 680 km^2 in extent. It covers a diverse landscape, including Lake Kyoga itself, numerous wetlands and various catchments. Its characterized by a complex of lakes, including Lake Kyoga, Bisina and Kwania as well as wetlands. The zone is also known for its significant fisheries, particularly the Nile perch. The KWMZ extends across several districts in the central region where the lake flows, such as Amolatar, Apac and Dokolo. It is a crucial area for water resource management with efforts underway to restore catchments and improve water quality KWMZ (Figure 1-5)

The Sironko sub-catchment is a sub-Catchment within Awoja catchment as indicated in Figure 1-5 and Figure 1-6.

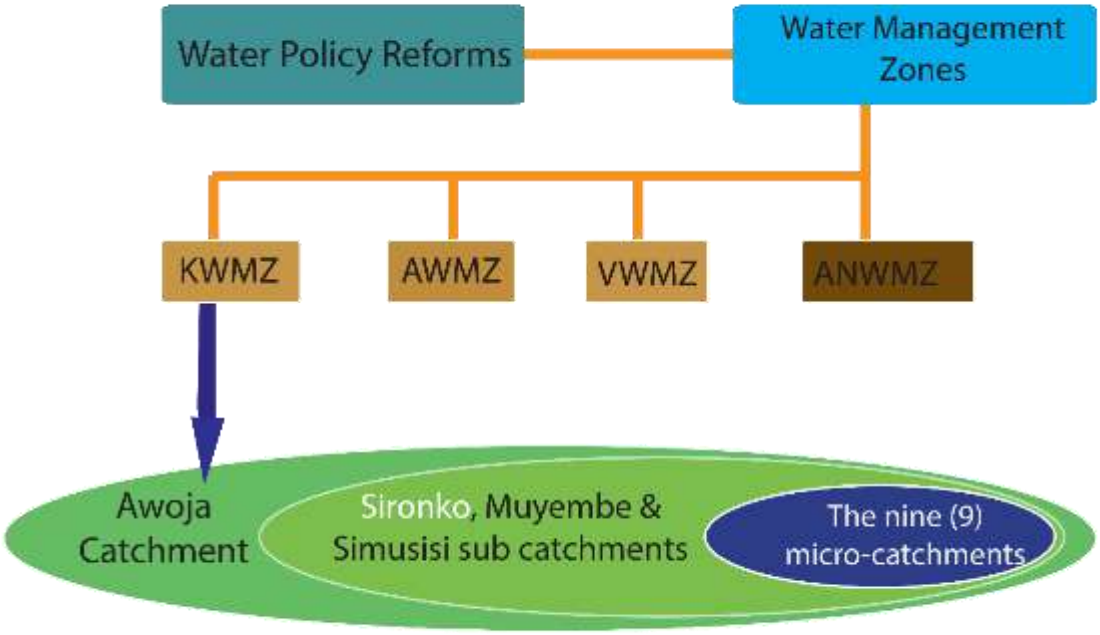


Figure 1-6: Management Structure of Awoja Catchment

2 DESCRIPTION OF THE CATCHMENT

2.1 Location

Lower Muyembe Micro-catchment covers an approximate total area of 49.55 km^2 in both Bulambuli and Kapchorwa districts.

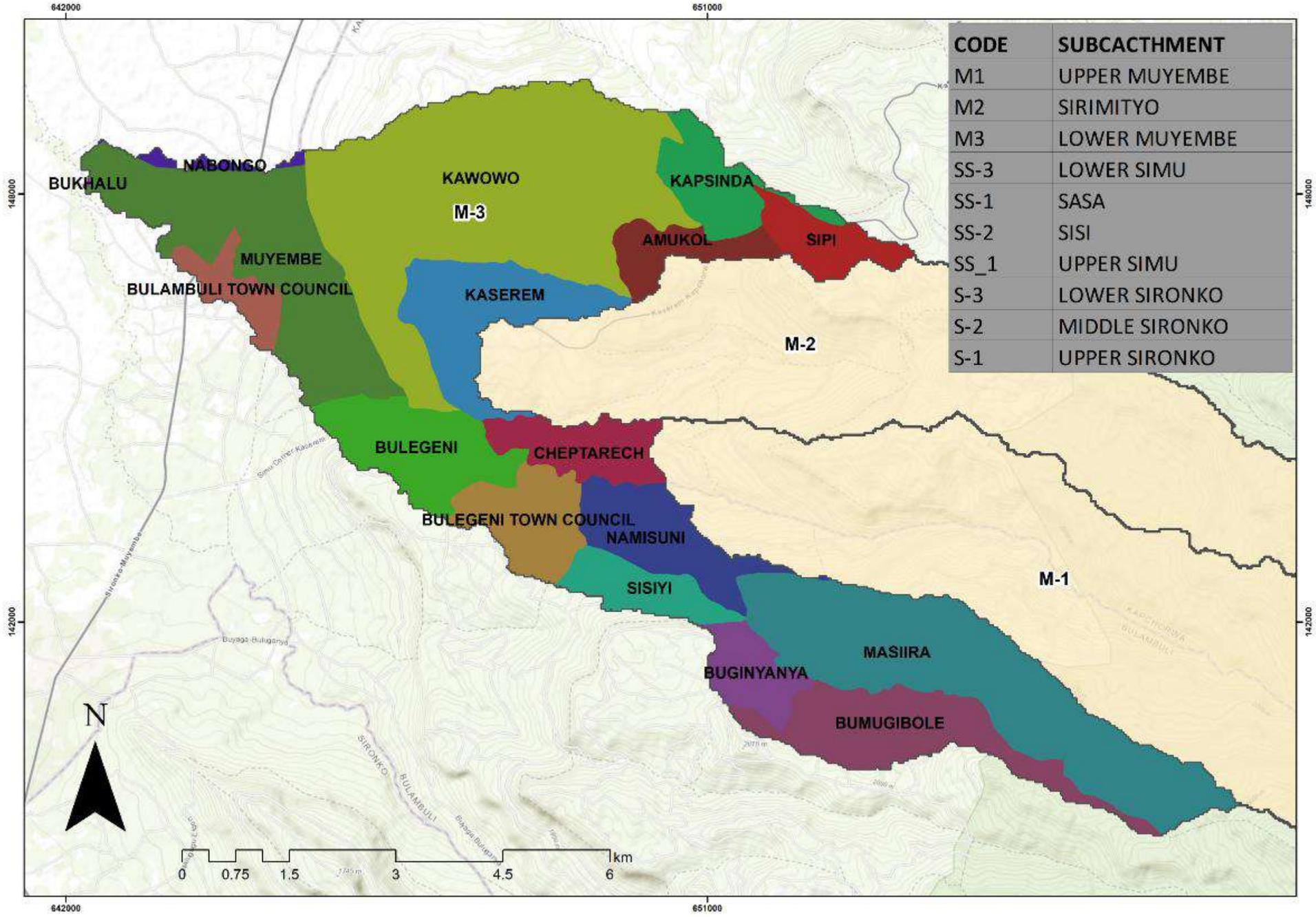
The Micro-catchment consists of the following administrative units: Amukol Sub-county, Buginyanya Sub-county, Bulambuli T/C, Bulegeni Sub-county, Bulegeni T/C, Bumugibole Sub-county, Chepteret Sub-county, Kamu Sub-county, Kapsinda Sub-county, Kaserem Sub-county, Kawowo Sub-county, Masiira Sub-county, Muyembe Sub-county, Nabongo Sub-county, Sipi Sub-county and Sisiyi Sub-county as shown in Figure 2-1.

The Micro-catchment is located within the Muyembe Sub-catchment of 151.27 km^2 which is part of the greater Awoja catchment of approximately 11,000 km^2. The distribution of the catchment amongst the different administrative units is summarised in (Table 2-1) below.

The Greater Awoja catchment straddles in over 14 districts (Katakwi, Nakapiripirit, Amudat, Kumi, Amuria, Soroti, Serere, Ngora, Bukedea, Sironko, Bulambuli, Kween, Bukwo, and Kapchorwa). It lies in the Kyoga Water Management Zone (Figure 2-1) under the decentralized water resources management in Uganda. Lower Muyembe is therefore a Micro-catchment within Muyembe sub-catchment (Figure 2-2)

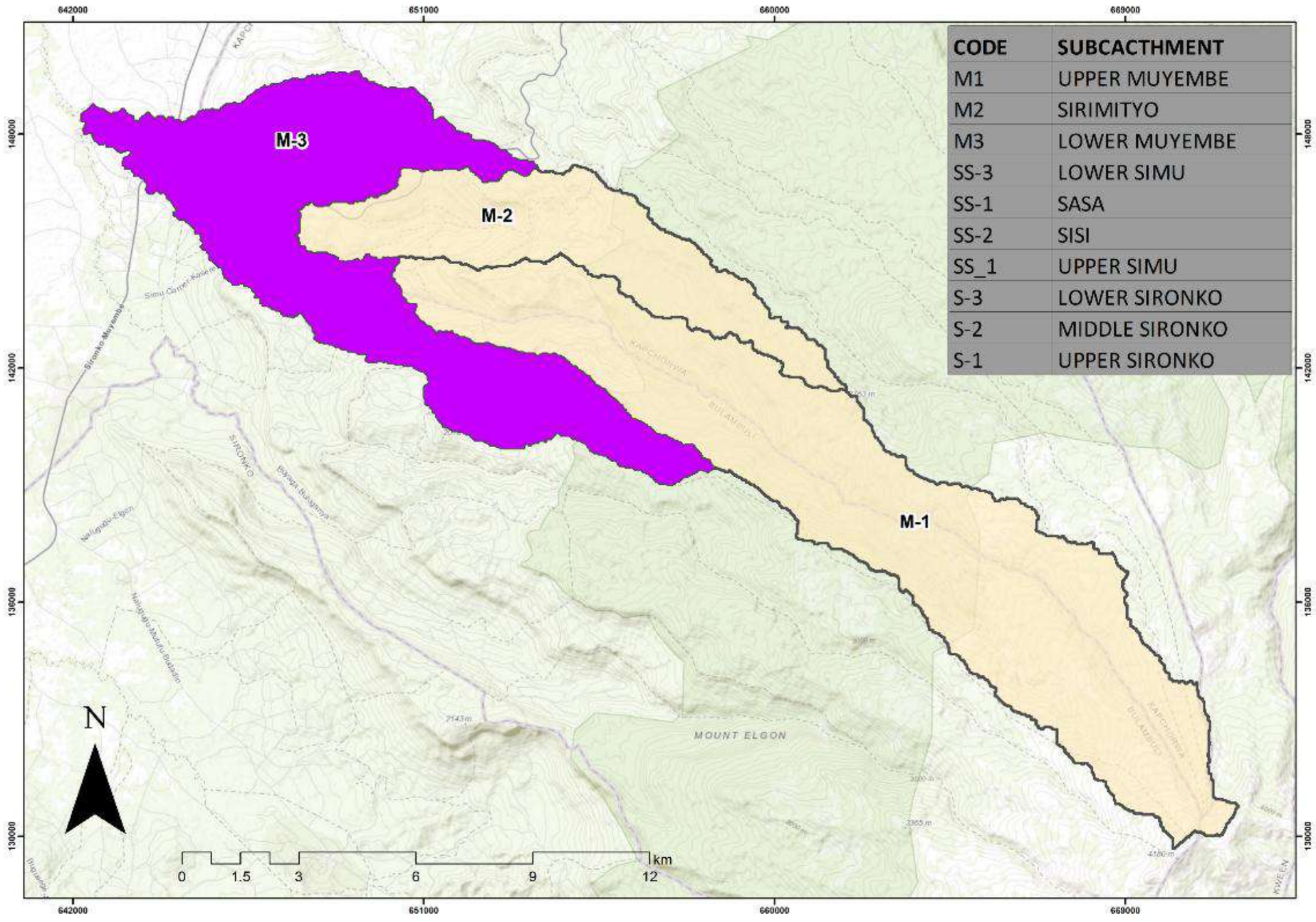
Table 2-1: Lower Muyembe Micro-Catchment surface area coverage by Sub-county

Sub-county	Area (km^2)	Percentage (%) coverage in the Micro-catchment
1. **Kaserem**	3.086	6.23
2. **Kapsinda**	1.712	3.45
3. **Kawowo**	12.377	24.98
4. **Amukol**	1.199	2.42
5. **Cheptarech**	1.661	3.35
6. **Sipi**	1.245	2.51
7. **Nabongo**	0.208	0.42
8. **Bumugibole**	3.365	6.79
9. **Buginyanya**	1.262	2.55
10. **Bulambuli town council**	0.935	1.89
11. **Bulegeni town council**	1.978	3.99
12. **Muyembe**	5.975	12.06
13. **Bulegeni**	2.766	5.58
14. **Sisiyi**	1.350	2.72
15. **Namisuni**	2.325	4.69
16. **Masiira**	8.106	16.36



CODE	SUBCACTHMENT
M1	UPPER MUYEMBE
M2	SIRIMITYO
M3	LOWER MUYEMBE
SS-3	LOWER SIMU
SS-1	SASA
SS-2	SISI
SS_1	UPPER SIMU
S-3	LOWER SIRONKO
S-2	MIDDLE SIRONKO
S-1	UPPER SIRONKO

Figure 2-1: Administrative units in Lower Muyembe micro-catchment



CODE	SUBCACTHMENT
M1	UPPER MUYEMBE
M2	SIRIMITYO
M3	LOWER MUYEMBE
SS-3	LOWER SIMU
SS-1	SASA
SS-2	SISI
SS_1	UPPER SIMU
S-3	LOWER SIRONKO
S-2	MIDDLE SIRONKO
S-1	UPPER SIRONKO

Figure 2-2: Location of Lower Muyembe Micro-catchment in Muyembe sub-catchment

2.2 Hydrology

2.2.1 Introduction

Sironko, Simu Sisi and Muyembe Sub-catchments are well drained with a dense network of meandering rivers which plays a fundamental role of the hydrological cycle thus need to be preserved and protected effectively to maximise their functionality. The river beds are filled with silt and characterized with substantial variations in low and peak flows, with a very quick response to extreme events, and ephemeral water availability in flood prone areas. Bank erosion was profuse with high levels of sediment deposition due to poor soil and water conservation measures on the agricultural landscapes. Rivers were used for domestic water, livestock watering, hydropower, clothes washing and small scale irrigation along River banks.

All the upstream rivers drain into the three large lakes inter alia; Lake Bisina, Lake Opeta, and Lake Okolitorum and associated swamps, cumulatively with an open water area of approximately 25,000 Ha. Permanent swamps are peripheral to the lakes, above which each inflowing river has a seasonal floodplain. A Large volume of surface water is absorbed and stored in wetlands thus expended as fresh water retention reservoirs that replenish aquifers, flood attenuation, sediment capture and opportunities for eco-tourism. Thus need to conserve upstream agricultural landscapes to ameliorate their functionality in providing the aforementioned services.

Downstream, the river continuously meanders due to extreme siltation and random deposition of boulders of different sizes, which reduces the river conveyance capacity. Consequently, flash floods are a common occurrence in the catchment. Previous studies have also attributed these floods to climate and land use changes (Jacobs et at., 2016).

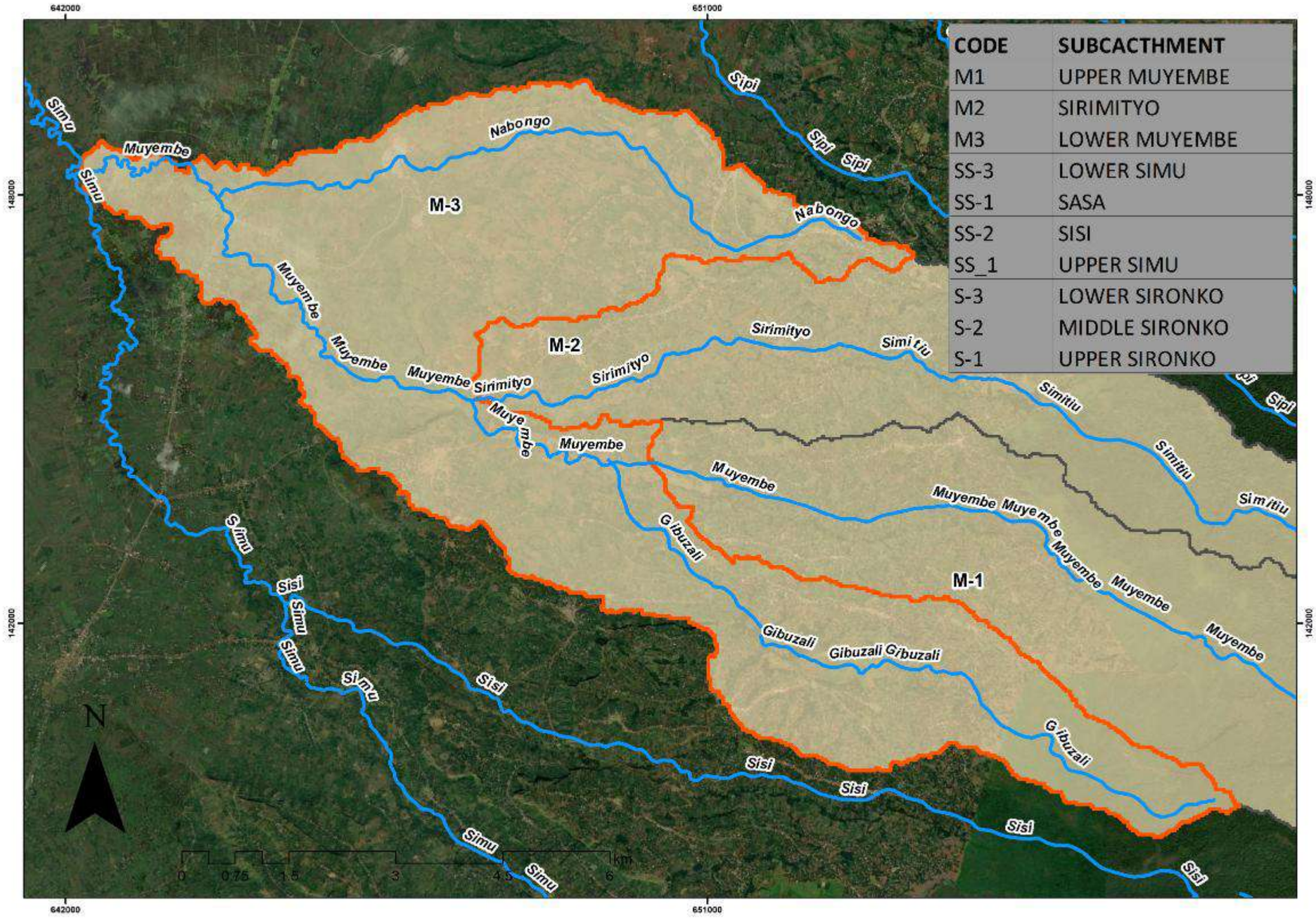
Following the hydrological drainage, micro-catchments were delineated in the Awoja catchment (Figure 2-4). The Micro-Catchments have been named according to the streams draining them. Table 2-2provides the list of the micro-catchments and their respective areas.

2.2.2 Delineated Micro-catchment in Muyembe sub-catchment

Lower Muyembe micro-catchment was delineated within the Muyembe Sub-catchment (Figure 2-4). The micro- catchment has been named according to the streams draining it. The table below provides the list of the micro-catchments and their respective areas.

Table 2-2: Delineated Micro-catchment

Sub-catchment	Delineated Micro-catchment	Area (km^2)
Muyembe	1. Upper Muyembe	75.42
	2. Sirimityo	26.66
	3. Lower Muyembe	**49.19**
Simu Sisi	1. Sasa	67.44
	2. Sisi	55.27
	3. Lower Simu	54.75
Sironko	1. Upper Sironko	90.29
	2. Middle Sironko	92.25
	3. Lower Sironko	93.67



CODE	SUBCACTHMENT
M1	UPPER MUYEMBE
M2	SIRIMITYO
M3	LOWER MUYEMBE
SS-3	LOWER SIMU
SS-1	SASA
SS-2	SISI
SS_1	UPPER SIMU
S-3	LOWER SIRONKO
S-2	MIDDLE SIRONKO
S-1	UPPER SIRONKO

Figure 2-3: Hydrology in Lower Muyembe Micro-catchment.

2.3 Topography and schematization

The Sub-catchments lie between 4304 – 1105 masl on the western side of Mt. Elgon with its highest peak Wagagai at 4321 masl. The lower relatively flat area has large peneplains and seasonal, fed by the high orographic rainfall that occurs as a result of the ring of surrounding mountains and drains towards Lake Kyoga and the Nile (Awoja CMP). Rivers originate from the veldt of Mt. Elgon National Park with pristine waters (Figure 2-4) and drain into Lake Opeta and Bisina. In piedmont areas, poor soil and water conservation measures have significantly impaired the integrity of the agricultural landscapes making them susceptible to soil erosion.

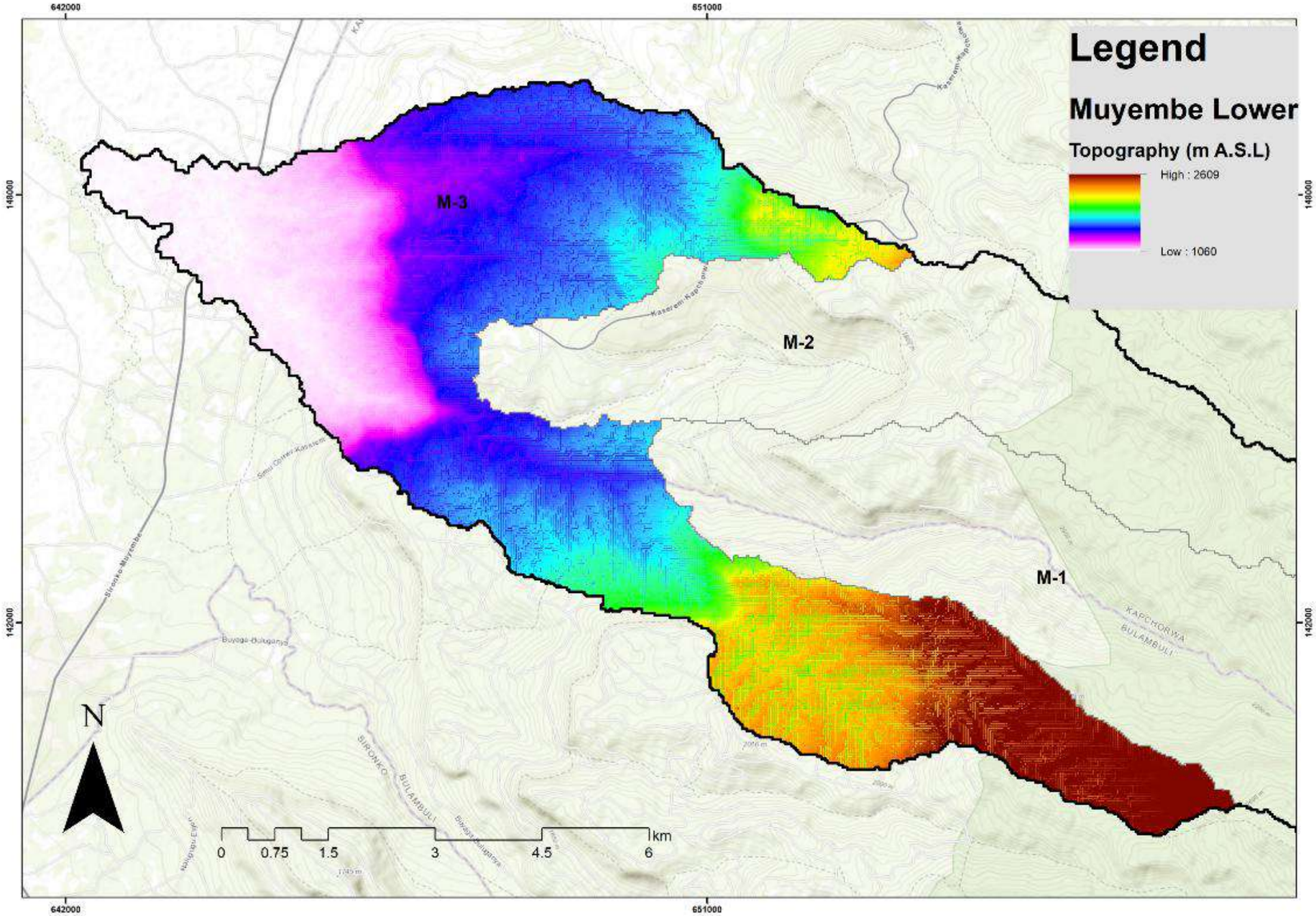


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Figure 2-4: Lower Muyembe Micro-catchment topography

2.4 Geology

The upper and middle micro-catchments of Sironko Sub-catchment are dominated by alkali volcanic formations and associated sediments (***Photo 2-1***), alluvial, black soils, moraines and banded Gneisses while lower micro-catchments are dominated by Gneisses - Granulite complex with some Quaternary sediments (Awoja CMP). The gravitational tilt in the landscape also aggrandizes the erosion processes resulting in high levels of silt and sedimentation downstream after heavy downpours or increased water levels in the river.

Photo 2-1: Sedimentary movements as a result of erosion

2.5 Soils

Kapchorwa and Bulambuli Districts have soils that are mainly sandy loam and are associated with limited amounts of plant nutrients due to leaching, erosion, volatilisation, and poor farming practices. Downstream District soils were mainly ferralitic (sandy sediments and sandy loams), well drained and friable. Kapchorwa District situated in Mt. Elgon high farmlands mainly from volcanic parent material, exhibits typically red clay loam, well-drained, highly leached, often acidic, but high in nutrients).

Generally, the area exhibits high soil erodibility with moderate rainfall. Soil erosion and siltation are undeniably a major environmental risk in the Sub-catchment and will be the dominant consideration in soil and water conservation management.

Photo 2-2: Peak rainfall events triggers the propensity to land and mudslides

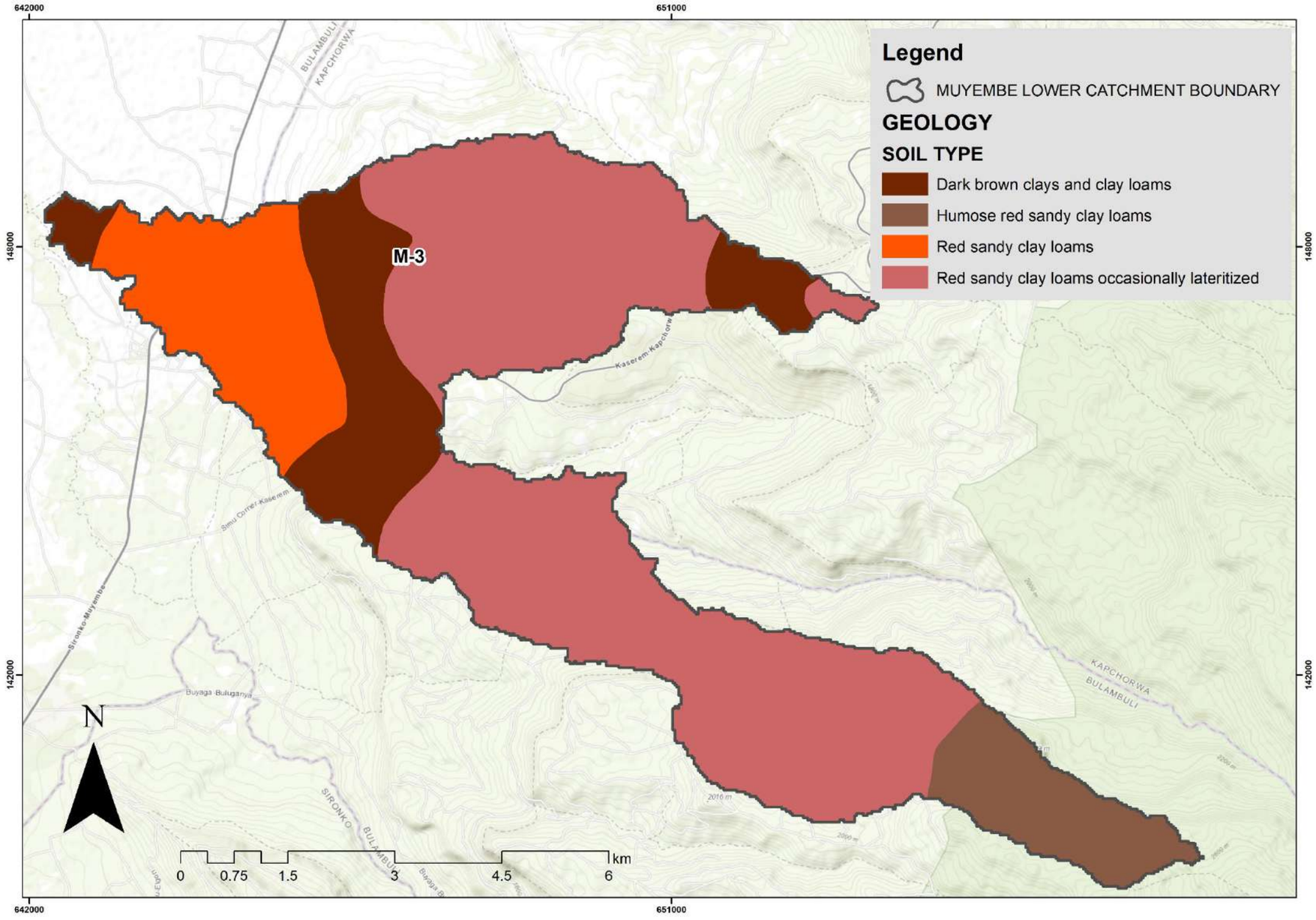


Figure 2-5: Lower Muyembe Micro- catchment soil types

2.6 Land use and land cover

2.6.1 Vegetation

The main vegetation types in the Project area include tropical high forests, woodlands, bushlands, grasslands and wetlands. However, due to increased population, there is a progressive reduction in the extents of these vegetation types over the last ten years as more land is converted into farmland (both commercial and subsistence) and built-up areas/ settlements (2010 to 2020).

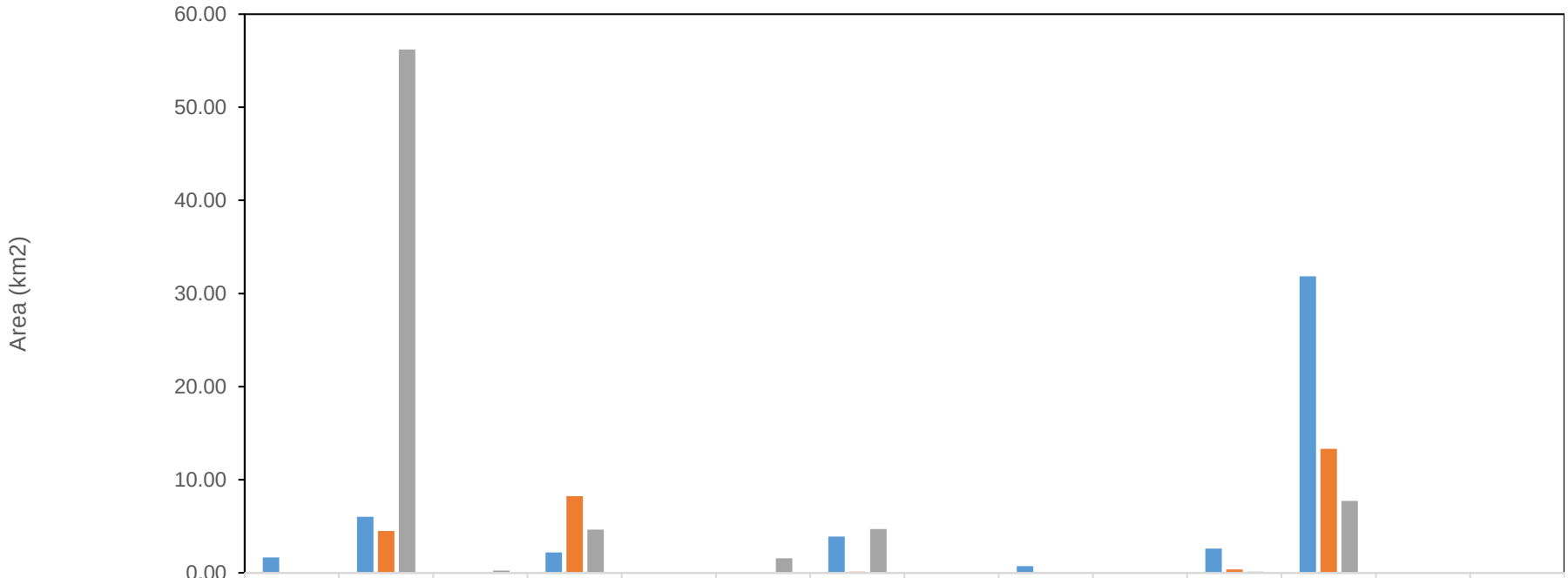
Most of the hill-tops in Kapchorwa, Sironko and Bulambuli districts are forested. Particularly for Mount Elgon, mixed mountainous forests are found at altitude less than 2500 masl. Bamboo and low canopy mountainous forest are found between 2400 masl to 3500 masl. Moorland is found above altitude 3500 masl. Open savannah to the north of these districts is sparsely populated due to Cattle rustling.

The largest protected area in the project area is the Mount Elgon National Park located in Kapchorwa, Bulambuli, Kween, Bukwa and Sironko districts. However, due to increasing population pressure, protected areas are being encroached upon as land to settle and farm on becomes scarce, especially in the northern parts of the catchment. Harvesting of forest products from conservation and protected areas is forbidden but the local people continue to harvest fire and other forest products resulting in conflict at their boundaries. Other encroachments have been for grazing and cropping.

The vegetation of Mount Elgon National Park is largely influenced by elevation and five distinct zones identified. These include grasslands at an altitude of 1000 - 2000 masl, Montane forest 2000 - 3000 masl, bamboo/mimolopsis zone at 2,500 - 3,500, healthier/riparian zone 3,000 - 4,000 masl and the afro-alpine moorland zone 4,000 - 4,500 masl.

2.6.2 Land use

Lower Muyembe Micro-catchment is part of Mt. Elgon region with closed grassland, dense natural forest, dense woodland, moderate natural forest, open bushland, open grassland, open land, very minimal settlements and subsistence cropland as presented in Figure 2-6



	Closed Grassland	Dense Natural Forest	Dense Woodland	Moderate Natural Forest	Moderate Woodland	Open Bushland	Open Grassland	Otherland	Settlement	Sparse Natural Forest	Sparse Woodland	Subsistence Cropland	Water Body	Wetland
LOWER MUYEMBE	1.65	6.01		2.19	0.05	0.00	3.91	0.00	0.71	0.01	2.61	31.85		0.06
SIRIMITYO	0.00	4.50		8.24	0.01		0.13	0.02		0.00	0.35	13.33	0.00	
UPPER MUYEMBE	0.00	56.19	0.25	4.65	0.03	1.57	4.71				0.12	7.72	0.02	

Figure 2-6: Land-use Land cover distribution in Lower Muyembe Micro-catchment

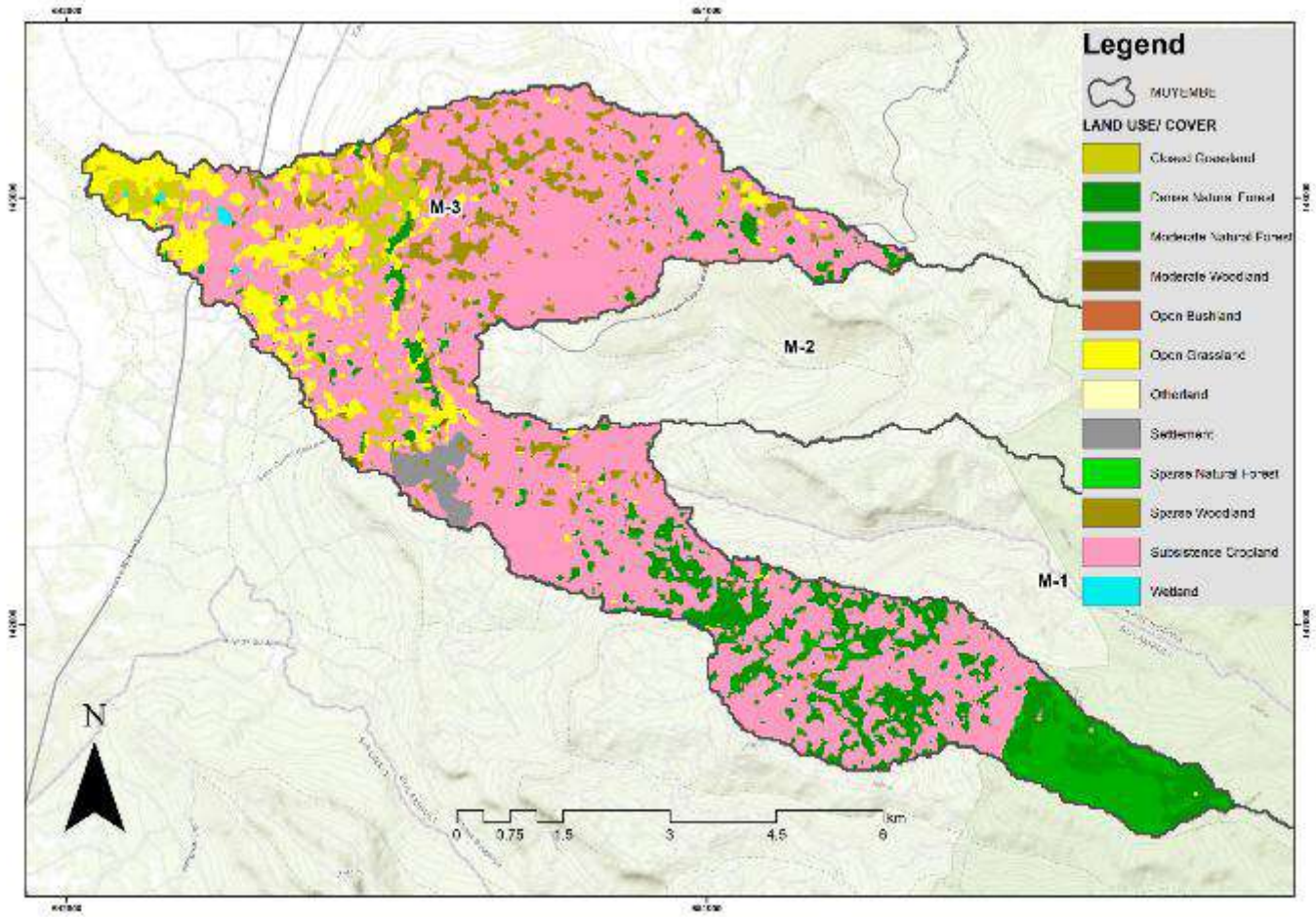


Figure 2-7: LULC cover distribution in Lower micro-catchment (see M-1)

Photo 2-3: Vegetation cover dominated by crops in Masiira sub-county

Photo 2-4: Tree planting on the slopes

2.6.3 Environmental degradation: Deforestation, soil erosion, Land and mudslides

Severe soil erosion and flooding is experienced in the sub-counties of lower Muyembe micro-catchment more especially in Nabongo, Kamu, Masiira, and Muyembe sub-counties is attributed to poor farming practices, cultivation of hilltops, over use of artificial fertilisers and encroachment of the river banks. The resultant effect of soil erosion has led to low crop yields, siltation in the river/dams and destruction of infrastructure i.e. roads and blockage of water supply systems.

Photo 2-5: Poor planning of settlements on the steep slopes aggravating the likelihood of soil erosion, landslides and vulnerability to rainfall related disasters

2.7 Climatological data

Rainfall distribution (Figure 2-8) in Eastern Uganda is bimodal and well spatially distributed, allowing two crops annually, and adequate grazing for livestock throughout the year. There is a long rainy season from mid-August to mid-November and a short one from March to May. The annual rainfall averages are about 1844.35 mm in the three catchments. Evapotranspiration data is among the hydrological components used to calculate the water

balance. Pre-processed MODIS evapotranspiration data retrieved from Google Earth Engine (GEE) platform, a cloud-based platform. The MOD16A2 product provides information about 8-day evapotranspiration (ET) at 1-km pixel resolution. The 8-day ET data were processed into monthly ET data for this study. Mean monthly Evapotranspiration was 105.43 mm/ year Evapotranspiration is more pronounced in Muyembe sub-catchment followed by Simu Sisi sub-catchment with highest peaks observed in January and August as shown in Figure 2-10.

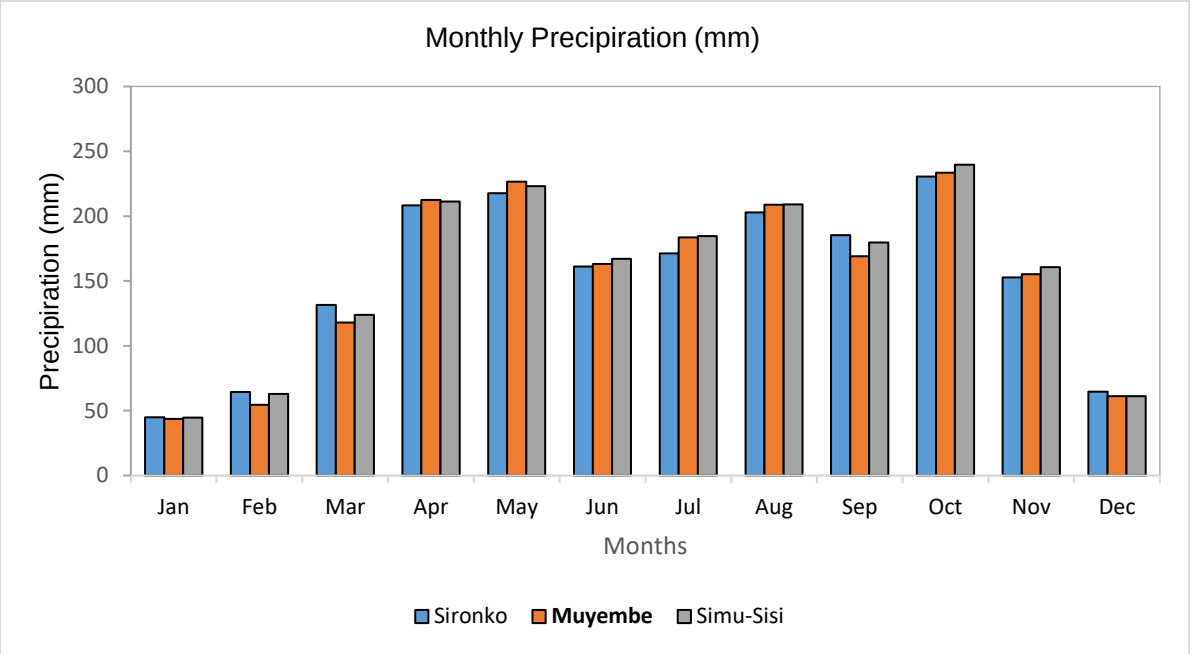


Figure 2-8: Monthly Precipitation distribution in the Micro-catchment

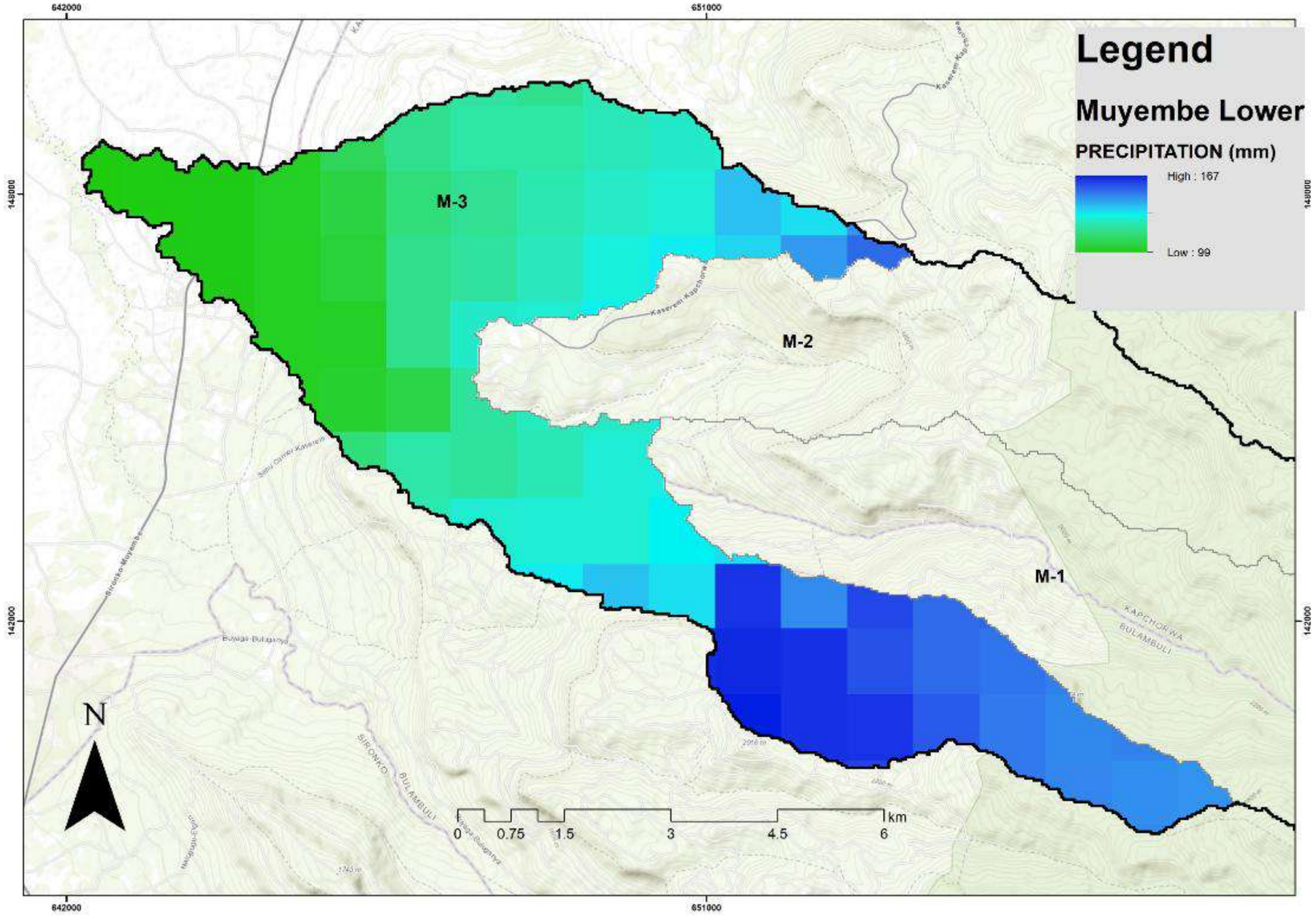


Figure 2-9: Monthly Precipitation distribution across the Micro-catchment (see M-1)

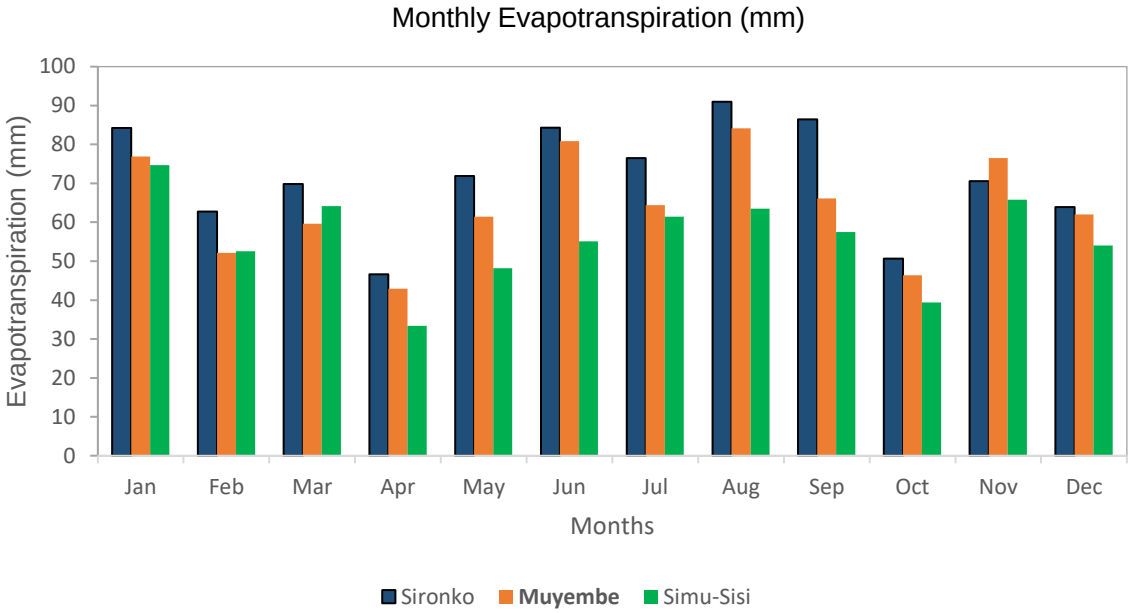


Figure 2-10: Monthly Evapotranspiration distribution in the Micro-catchments

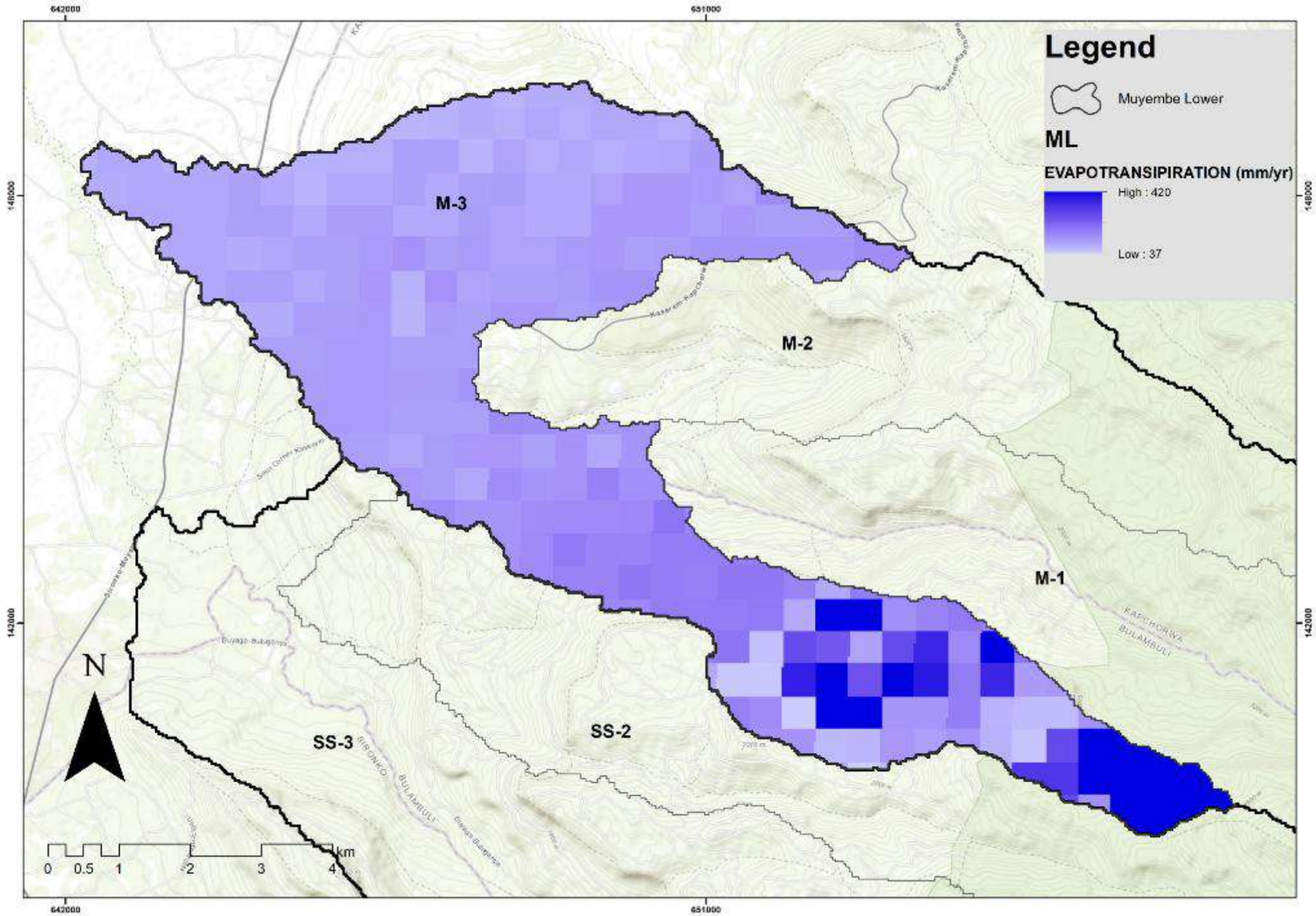


Figure 2-11: Annual Evapotranspiration distribution across the Micro-catchment (see M-1)

2.8 Building the catchment knowledge base

Knowledge base consists of all types of data and information including hardcopies or reports and maps as well as data in digital form. As the planning process proceeds new data will be added to the knowledge base. Without good data and information, no real planning can be done and no informed decisions can be taken. At the onset of the planning process, therefore, an important task is to collect, compile, and organize the needed data. Large part of proposed actions is important in order to collect necessary data to form a solid knowledge base and share information to prepare the adequate environment for the implementation of infrastructural and management actions. Data and information that is entailed in the Knowledge base includes;

- Bio-physical description of Lower Muyembe Micro-catchment
- Mapping and characterization of major issues
- Socio-Economic data (population and related census data, which can be compiled as attributes of the administrative boundaries)
- Spatial database (stream network, water sources, existing infrastructures, towns, land-use, administrative boundaries)

GIS is the tool needed to organize most of this data, but other tools and computer aided programs such as excel will also be needed. The knowledge base was organized and will be implemented in a manner that facilitates wide access to the data and provides a focal point for water related data and information in the KWMZ, with data collected by various national and other agencies being collated in the knowledge base. In addition to the queries, analysis, the information and maps will be used to generate various knowledge products such as atlases, state of the catchment reports.

During compilation of data and information, some of the identified shortcomings that require immediate actions during the implementation of the plan include new hydrological/ meteorological monitoring stations within the catchment.

In the course of updating the knowledge database, a computer model or paper map will not be substitute for field reconnaissance, i.e., for traveling throughout a catchment to see the many ways in which water is used, to observe the factors that govern the hydrology of the catchment such as soils, land-use/ cover, slope, and the stream network. This also provides an important opportunity for initial discussions with stakeholders not necessarily through formal gatherings but primarily impromptu discussions in the field with local people. This is also an opportunity to assess land-use changes, especially the expansion of agriculture and to obtain an appreciation of the timeline associated with these changes. In some cases, these changes may be both large and relatively recent and highly significant in terms of observed changes to the hydrological regime (e.g. base flow, floods, groundwater recharge etc.).

3 STRATEGIC SOCIAL AND ENVIRONMENTAL ASSESSMENT (SSEA)

3.1 Introduction

In general, SSEA is still relatively a new concept and its application in the country has mainly been donor-driven and/or voluntary. The National Environment Act, 2019; National Environment Management Policy, 2016 and National Environment Management Act 2019 all incorporated the principles of SSEA so as to main stream environmental and social issues into development.

Muyembe, Sironko and Simu Sisi SSEA was a systematic, analytical, participatory and comprehensive process for evaluating both social and environmental consequences of proposed catchment management plan and intervention projects, initiatives and alternatives to ensure that they are appropriately addressed at the earliest stage of decision-making. This SSEA will be a useful tool in guiding future planning and developments within the catchment.

At the strategic level, this SSEA assessed:

a) The major social and environmental issues in the catchment today and potential issues are in the future that the plan should foresee hence attempt to mitigate, taking into account the resource base and development opportunities that stakeholders desire.
b) The cumulative impacts of water resources developments and use in the catchment up to today, and what could be potential future impacts.
c) The issues and impacts that may influence how well the catchment plan achieves the planning goals and objectives.

At one end, the focus was on impact analysis and sustainability and at the other, on institutional assessment. This was aimed at improving awareness of the nature and significance of social and environmental issues in the catchment resulting from land use and development activities, to help stakeholders understand the potential implications of these issues and cumulative impacts, and to integrate them into the planning process.

3.1.1 Objectives and Scope of the SSEA

The main objective of this SSEA was to identify key social and environmental impacts at an early stage in the planning process so that consideration of these issues is given due during catchment management planning. Specifically, the SSEA was used to:

(a) Identify (at a strategic level) the most vulnerable social systems and communities, institutional systems, areas of natural habitat and sites of national heritage that are most likely to be affected by current and likely catchment interventions and future development, and associated infrastructure;
(b) Identify important environmental issues resulting from the current and expected future main land-use and development activities in the Micro-Catchment and the impacts (indirect and cumulative) that already have and will likely have on other economic activities, the environment, and socio-economic development.

(c) Assist in stakeholder engagements for capacity building, improved governance, facilitate trans-boundary co-operation around shared environmental resources, and contribute to conflict prevention.
(d) Incorporate sustainability considerations into decision-making and development.

3.1.2 The SSEA process had the following sequence;

1) Documenting baseline conditions (land use and socio-economic profile) of the catchment, including environmental vulnerability and quality.
2) Stakeholder engagement, including expert's consultation, and public consultation.
3) Development of strategic alternatives and linkages.
4) Prediction and evaluation of the social and environmental indirect and cumulative impacts, for current and expected new developments including proposed intervention projects.
5) Formulation of mitigation measures for the identified adverse impacts and proposing mitigation plan.
6) Proposing measures to monitor environmental and social impacts of implementing the plan.
7) Describing implementation arrangements.

OUT PUT: **Strategic social and environmental mitigation and monitoring plan** a mirror of the **catchment management interventions matrix**; identifying practical and bankable measures that will help to secure its recommendations, and in setting out time scales, milestones, and responsibilities for action.

3.2 Assessment of the Socio-economic situation in the catchment

3.2.1 Social-economic Baseline

The demographic, social and economic characteristics of the Sironko sub-catchment was assessed. This baseline was used to assess the socio-economic situations within the catchment and how possibly that can influence catchment management planning. The baseline also provided an overview of the key socio-economic indicators in the project area, as well as a review of attitudes and expectations, focusing on qualitative and quantitative data from the communities that lie within these sub/micro-catchments. The baseline study covered villages from the delineated parishes targeting various institutions, industries and agencies within the micro-catchments.

Rationale for socio-economic studies:

Understanding the dynamics of the catchment and setting benchmarks for implementation needs a clear understanding of baseline conditions in the catchment. The socio-economic baseline studies aimed at understanding activities, livelihoods, ownership of land extent of land use and settlement patterns among others so that they can be integrated into catchment management planning. Additionally, the study is informed by the fact that in all other catchments, socio-economic activities were the main reasons for catchment degradation.

Approach:

The socio-economic assessments included conducting household surveys, asset mappings that were enhanced by other tools (i.e. seasonal calendars, livelihood framework, gender analysis framework, and resources mapping), focus group discussions, semi-structured interviews, transect walks and secondary data analysis.

3.2.1.1 Historical Perspective of the Muyembe, Sironko and Simu Sisi Catchment

River Sironko, flowing from Mt. Elgon in Eastern Uganda, has a history intertwined with the livelihoods and challenges of the Sironko, Bulambuli and part of Kapchorwa districts. The river and its surrounding area have faced issues like soil erosion, flooding, and environmental degradation due to various land uses. The river's water quality is also impacted by agricultural practices and human settlements near its banks.

The area, once part of Bulambuli and Budadiri counties, became Sironko District in 2000. Sironko town, now the district headquarters, is located at the foothills of Mt. Elgon and is known to be susceptible to landslides and flooding.

The Sironko River catchment is hydraulically and biologically linked to Lake Kyoga through a series of smaller lakes and swamps. It also serves as a spawning ground for certain fish species found in Lake Kyoga.

Analysis of satellite imagery over several decades shows a significant increase in agricultural and residential areas within the Sironko Muyembe and Simu Sisi catchments, highlighting the need for sustainable land management practices.

These sub-catchments are located in Bumasaba Kingdom. The kingdom is made up of six districts: Sironko, Manafwa, Bududa, Mbale, Namisindwa and Bulambuli. The Kingdom is led by a cultural leader (Omukuka), and is recognised as an independent cultural institution. (KRC and RFPJ. 2012)

The foregoing is important because catchment management as an integrated strategy needs to capture issues of tribal conflicts as well as understanding the relationships between cultural groups and how this can impact on the success of the management plan.

3.2.1.2 Demography and Population

Population size and density:

Population size

The population of Kapchorwa and Bulambuli districts where the study is being under taken is **279,093.** The population of Bulambuli and Kapchorwa Districts where Muyembe sub-catchment and Lower Muyembe micro-catchments are located is about 174,513 and 104,580 people respectively. The average population growth rate of these districts is about 3.4% and is above the national average of 2.8%.

The estimated rural population in the two districts is around 78.9% of the population is rural. Only 5.46% of the population is aged over 60 years.

Table 3-1: Population distribution in the hotspot districts

Balambuli	**Males**	86,108	**174,513**
	Females	88,405	
Kapchorwa	**Males**	53411	**104,580**
	Females	51169	

(Source: UBOS, 2014)

3.2.1.3 Ethnic Composition

Ethnicity is the state of belonging to a social group with common culture, tradition and language. Ugandans are classified by ethnic groups as listed in the Constitution of the Republic of Uganda. There are 65 ethnic groups in Uganda with the Baganda (17%) being the majority followed by the Banyankole (10%) (UBOS 2014).

Majority of the population in the project area belongs to Bagisu (Gisu). The Bagisu primarily inhabit the Masaba land, which includes Sironko and Bulambuli.

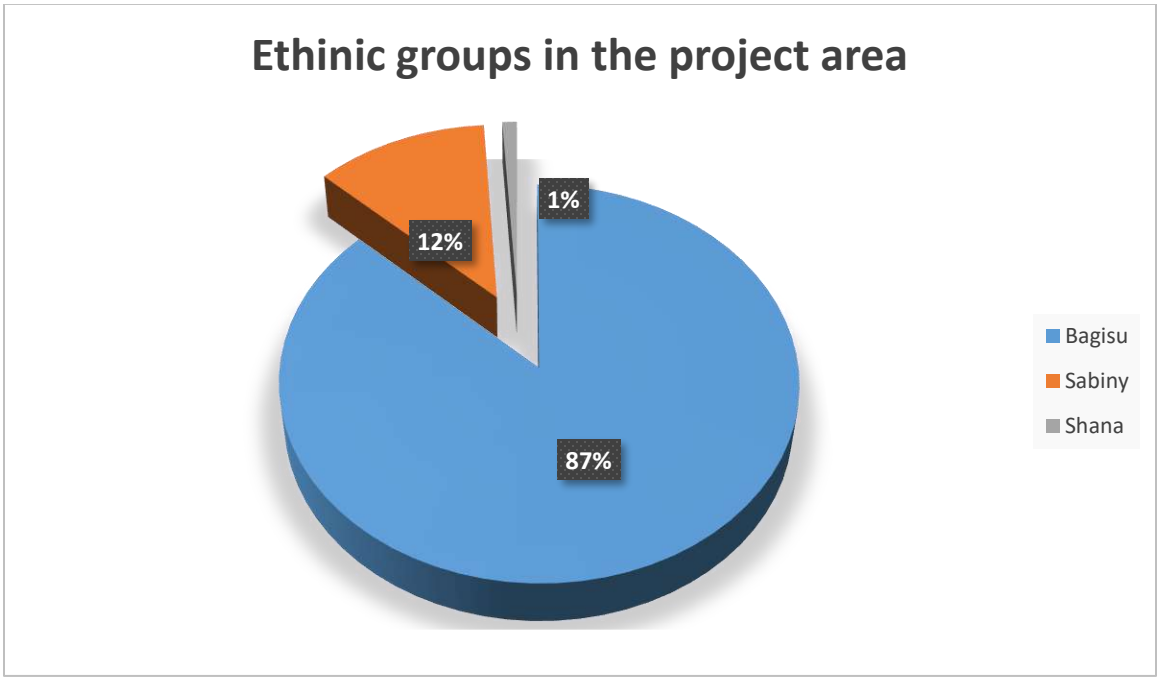


Figure 3-1: Data source-primary household survey findings

Ethnicity plays a great role in any project planning and implementation. Any planning should therefore take into consideration interests and views of all tribes in the catchment but more importantly that of the Bagisu due to their status as the majority group.

The main languages spoken in the project area are Lumasaaba also known as Lugisu. Lumasaaba is dominant language in Bulambuli and Sironko. Kiswahili and English are also used for communication across different ethnic groups in formal settings.

3.2.1.4 Culture, Traditions and Religion

Bagisu culture follow a patriarchal structure. Traditional cultural practices and beliefs may be harmful to women's rights (*e.g.* limited access and control over land, domestic violence, accusation of witchcraft, early marriage, low education level, exclusion from decision-making processes and economic vulnerability). Marriage is a highly respected social institution in the area. 81.0% of the respondents to the socio-economic survey were married (Figure **3-2**).

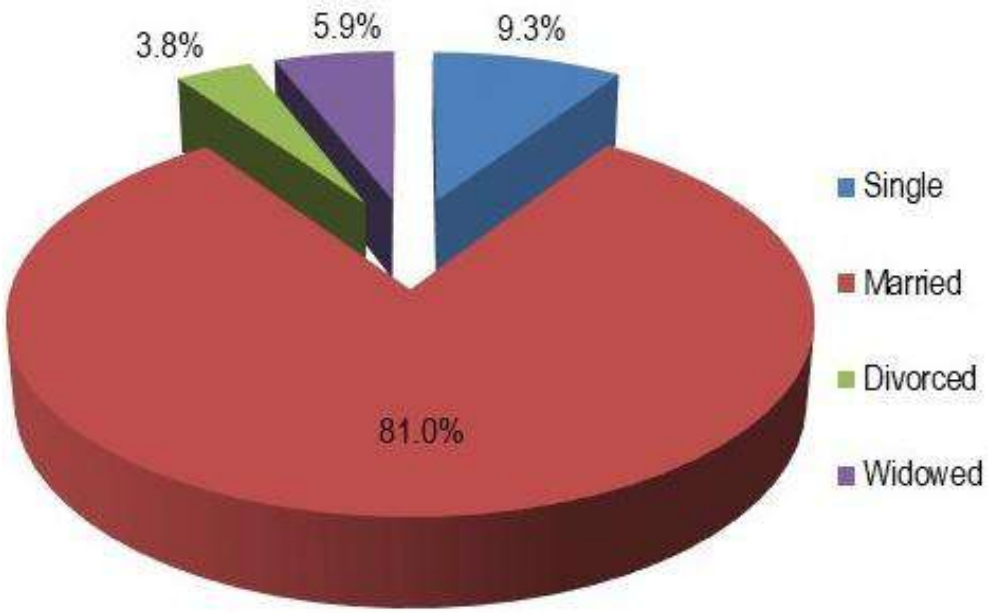


Figure 3-2: Marital status of the respondents

Religion

Uganda is characterized by a diversity of religious beliefs and practices. Catholics (40%) are the largest religious denomination in Uganda followed by Anglicans and Moslems (UBOS 2014). Only 1% of Ugandan citizens describe themselves primarily as practitioners of traditional local religions, but such practices endure among many people who identify as Christian or Muslim. Survey respondents were largely reluctant to disclose their ancestral practices and denied to practice traditional rituals in the public space. These practices, however, seem to actually persist in the private spheres. The population within the project area is predominantly Protestant (45.7%) followed by Catholic (29.1%) then Moslems (14%) while the Pentecostal/born again Christians account for (5.3%) (Figure **3-3**). During catchment management planning and eventual implementation of the plans, religious leaders need to be greatly involved, especially the protestants and Catholics, because they command great influence and power.

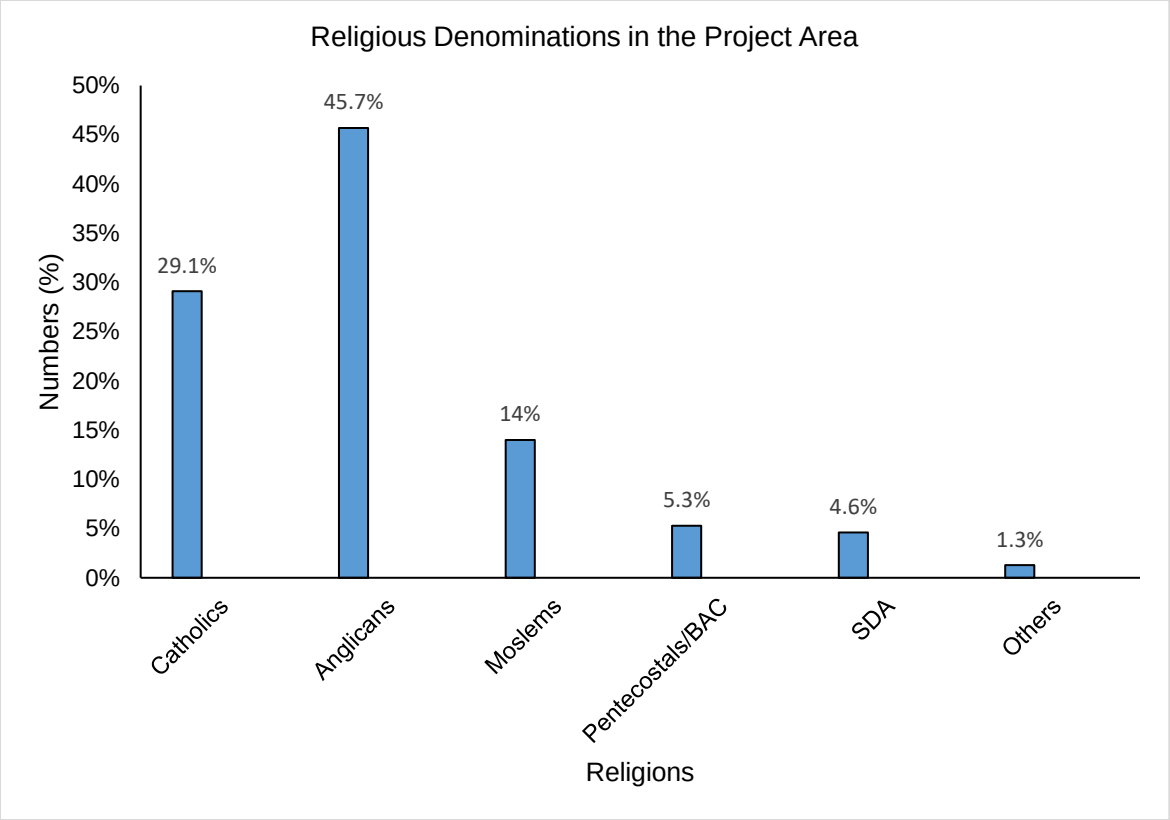


Figure 3-3: Religious denominations in the project area

3.2.1.5 Social Organisation

Gender roles

The organisation of women daily activities was strongly influenced by seasonality and their place of residence. These roles are largely domestic including housekeeping, baby-sitting, fetching water, cooking and tending to community needs. While it has traditionally been the role of men to control familial financial matters, women provide substantial economic contributions to their families. From focus group discussions, women were found to be significantly involved in land-based activities such as cultivation and as such women should be strongly involved in catchment planning process as this would eventually affect the land use.

Agricultural activities are more intense during the rainy season (from February to June and August to December). During the dry season, farming activities are less intensive.

Although money management schemes vary from one household to another, men reportedly dominate financial decision making. The gender imbalance in decision-making is even more pronounced for important investments such as land, livestock and building material for the house for which men take most, if not all decisions. Women are responsible for small expenses involving purchase of food, household supplies, paraffin, soap and clothing. Although men are expected to

pay for school fees and health care, women often complain that men spend considerable household money on alcohol and fail to provide for families.

Photo 3-1: Woman fetching firewood

Photo 3-2: some of the gardens around the homesteads

Photo 3-3: working in weekly markets

Photo 3-4: Drying agricultural produce

Community self-help groups and support networks

A number of Village saving and Lending Associations (VSLA) and self-help groups at large have been reported in most of the villages. Residents pool their savings as a source for lending funds to group members: each member contributes regular savings deposits to a common pool, and members can take loans from those savings, paying back an acceptable interest. About 80% of respondents to this household survey belonged to a community self-help group. Group memberships and roles played were also not gender segregated, even though the biggest membership group was women. The groups are mainly youth, women, tree planting and environmental conservation, livestock keepers and farmers' groups (especially coffee), as well as

credit and saving groups of mixed composition. These groups typically consisted of 30 - 50 members.

The main challenges reported included lack of training, lack of capital, defaulters, fluctuating participation of members and cases of money mismanagement. This come out mainly from the focus groups but also in the main questioner.

There is no direct linkage between community organisational capacity and the number of groups in the study area. Many of the groups have been initiated by outside organisations such as government programmes (*e.g.* NAADS, PDM) or NGOs (*e.g.* Caritas Uganda). These programs request prior to disseminating in-kind grants (goats, cattle, seeds, etc.) or trainings that local communities be organised into formally registered groups (registration process with the Community Development Officer). Within the project area, these VSLAs were represented in the micro-catchment management committees.

It is important that during the catchment management planning and implementation, these groups are continuously engaged because of their community influence but also picking from their existing mobilizing and sensitization structures on ground. Women that are key in as far as projects related to land use are concerned could be easily got from these organised groups.

3.2.1.6 Settlement and Housing

Settlement patterns

Community mapping within the project area was done. Emphasis was put on the infrastructure within the area and other resources and factors that would influence the settlement patterns within the catchment area. Town councils and other trading centres had the highest population amongst the sub-counties villages varied in size between approximately 100 and 700 households with the average number of people in a household being 8 (FDG).

The rural population consists about in the project area is estimated at 88% of the population while the urban population is 12% (Bulambuli DDP). In reference to land use and cover, the catchment area has three major human settlement patterns, based on the livelihood (grazing and cultivation), level of development (along Road network) and the nature of relief of the area.

Housing

The Universal Declaration of Human Rights of 1948 recognises the right to housing as an important component of human rights. Similarly, the Government of Uganda recognises the strategic social and economic importance of housing in the national economy and, particularly, to the socio economic transformation of the country as highlighted in Vision 2040 (MLHUD 2016). The characteristics of dwellings and various aspects of households living arrangements provide an important indication of the well-being of household members.

In the districts of Bulambuli and Kapchorwa, Uganda, housing types primarily consist of temporary and semi-permanent structures. The most common materials used for walls include mud and wattle, while roofs are often made with iron sheets. Some dwellings also feature permanent materials like concrete and brick.

Majority of the dwellings in the catchment are semi-permanent with a rising number of settlements along the river. The local leaders attribute this increase to high population growth of these district and land fragmentation due to inheritance practice in the catchment. The plan therefore must factor in solutions to increasing settlements within the study area.

3.2.2 Land Ownership

3.2.2.1 Tenure systems

There are four types of land tenure systems recognised in Uganda under the Constitution (Article 246) and the Land Act (Cap 227) (Republic of Uganda, 1998): customary tenure, freehold, leasehold and *Mailo*.

Majority of the respondents (66.8%) that participated in the survey owned land. Average land holding in the catchment was approximately 1 acre implying that issues of land fragmentation within the catchment may have to be dealt with during catchment management planning. Customary tenure (52%) is the predominant form of land ownership in the catchment (Figure 3-4 and Figure 3-5).

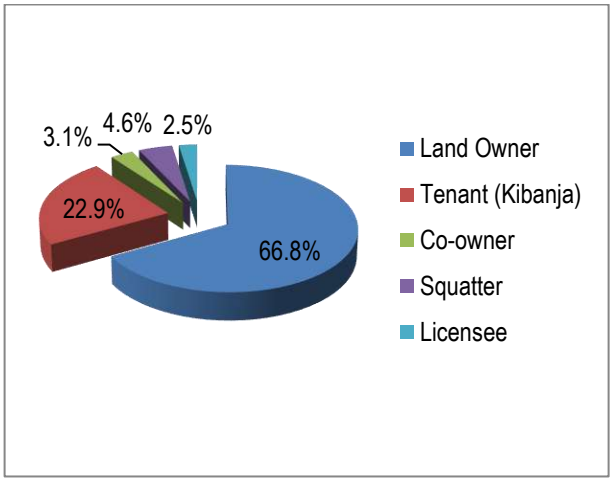


Figure 3-4: Land ownership in the project area

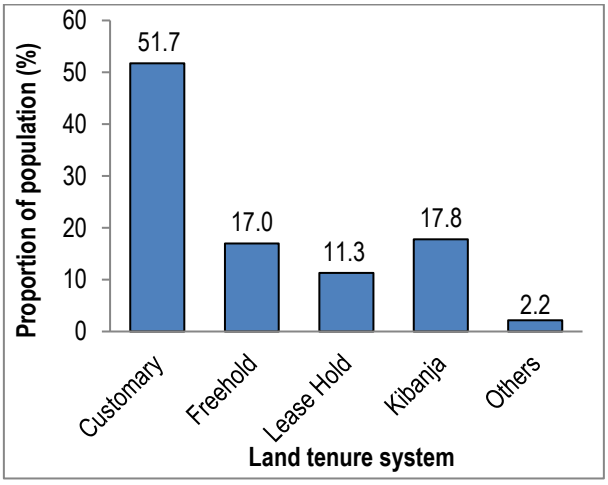


Figure 3-5: Land tenure systems in the project area

3.2.2.2 Land Access and Acquisition

Majority of the land owners in the catchment area acquired their land through purchase/ buying (50.7%). Other major forms of acquisition included inheritance (32.2%), renting (12.7%) and squatters (4.5%) (Figure 3-6).

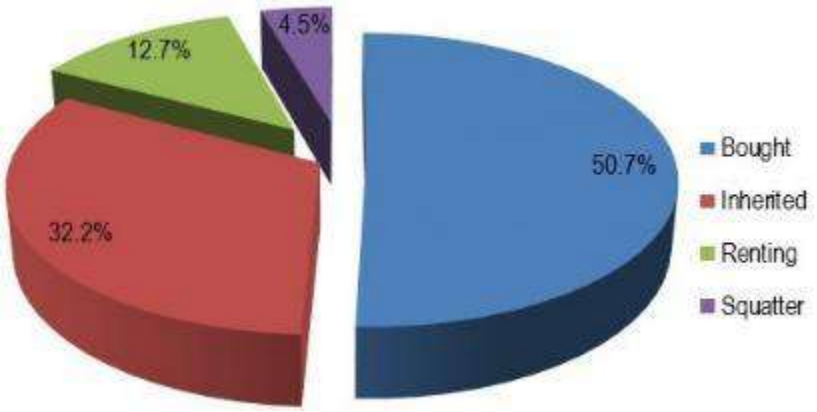


Figure 3-6: Method of land acquisition in the project area

Land related conflicts are also common in these districts and catchment areas. Specific land related conflicts are well known in the areas neighbouring the protected areas of NFA and the national park where there is massive encroachment. The report also indicates that the conflicts are normally between family members.

3.2.3 Social Infrastructure and Service Delivery

Access to water

The source of water is an important determinant of the health status of household members. Safe and clean water is a prerequisite for reducing many common killer diseases of both adults and children such as diarrhoea, dysentery and cholera. The importance of access to safe drinking water is underlined by the fact that it is one of the SDGs (SDG 6) and also in NDP II where during the plan period, government will focus on increasing access to safe water from 65% to 79% in rural areas and from 77% to 100% in urban area. The National Standard Indicator (NSI) for water coverage is the percent of households with access to water. In African households that collect water outside their residence, the burden reflects in the division of labour along gender lines within the households (Dos Santos, 2012). In line with socially-constructed gender roles, the burden of water collection and storage usually falls on the women and girls of a given household (UNDP 2006).

Generally, access to safe and clean water in adequate quantities in Uganda remains a major impediment to the country's human development. In the catchment area, the situation is not any different; a few options of water sources exist. Majority (60.8%) of the people depend on River Sironko followed by Yard taps/Public stand posts for water for domestic use (Figure 3-7 and Figure 3-8). This includes people who wash and bathe directly in the river. With such a proportion of the population relying on R. Sironko for their water supply needs, it is imperative that the river is not contaminated and is of the quality acceptable for domestic as well as industrial use.

Table 3-2: Water access in the project districts

District	Access (%)	Rural Functionality (%)	Equity
Bulambuli	64	84	70
Kapchorwa	79	97	131

(source: Uganda Water Supply Atlas 2025)

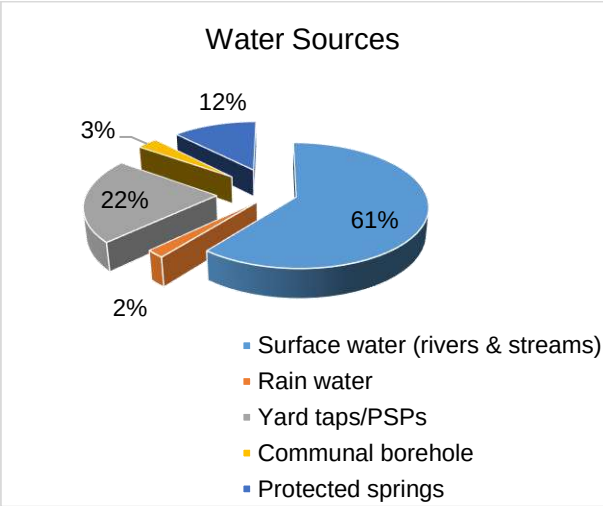


Figure 3-7: Sources of water

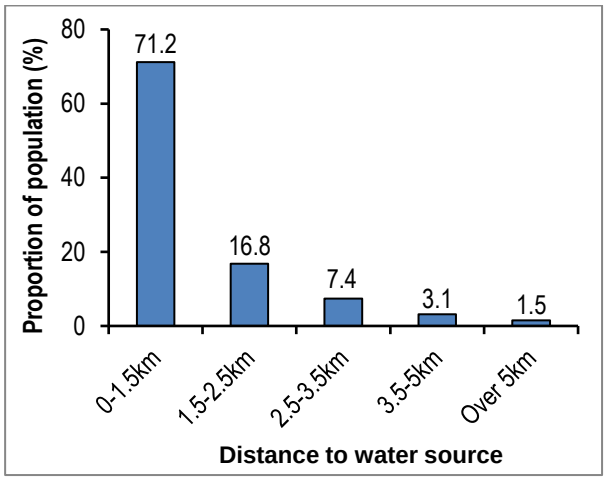


Figure 3-8: Distance to water source

Majority of the respondents (84.4%) access water throughout the year and think the water quality is good. Cleanliness of the water sources may need to be subjected to more studies as the responses could be as a result of perception of the communities since these are their sources.

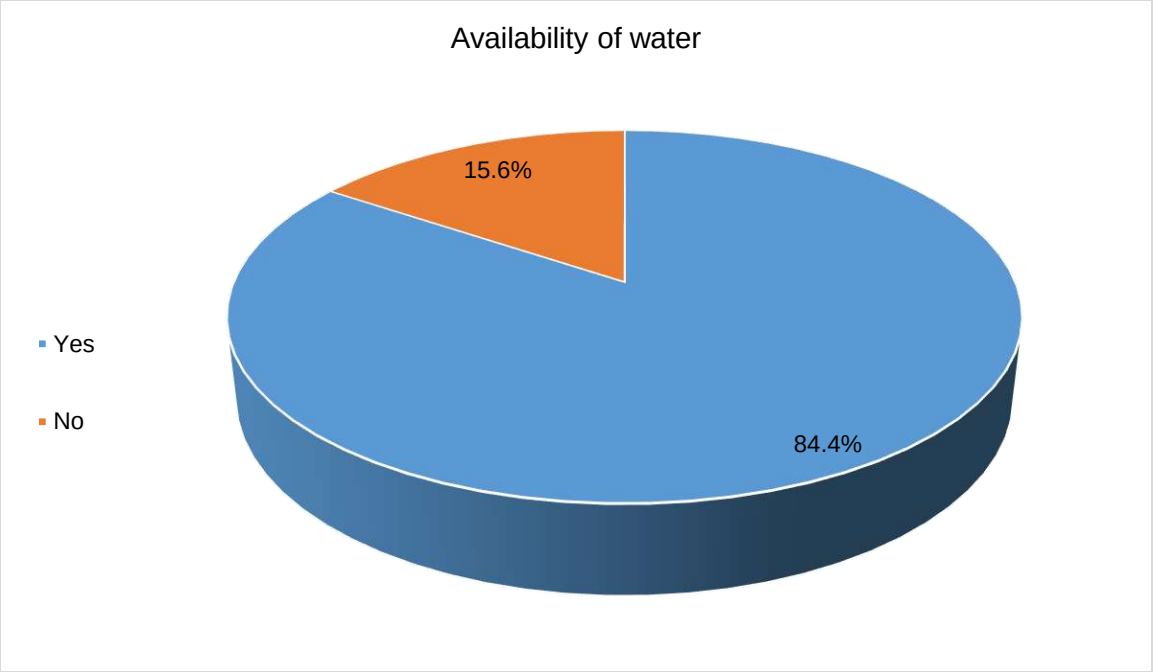


Figure 3-9: Water availability throughout the year

Human Diseases

Participatory assessments indicated that the most common disease epidemics experienced in Sironko district are; malaria, cholera, HIV/AIDS and respiratory tract diseases. It was reported that the HIV/AIDS prevalence rate was at 3.1% in Budadiri and Sironko Town councils. It was noted that malaria prevalence rates were very high and thus responsible for most deaths in the district. In early 2016, there was an outbreak of cholera in Budadiri and Sironko Town councils where 192 cases were registered and 4 people died.

3.2.3.1 Sanitation infrastructure

Sanitation is a critical component of human life and this is reaffirmed by the importance the SDGs and NDP II attach to it. SDG 6 goes beyond drinking water to also address sanitation and hygiene. The construction of sanitary facilities, especially latrines is considered challenging in some areas due to adverse environmental conditions. These conditions include the presence of hard rock at shallow depths, collapsing and loose soils, and high water tables, among others. This results in a lack of latrines in some households/ communities, especially in water-logged and flood-prone areas of Bulambuli and Sironko districts. The Ugandan Government has various sanitation policies and strategies to address sanitation and hygiene in the country. Due to limited funding for the sub-sector, however, implementation of these sanitation policies has not been adequate and effective, especially at Local Government Level (MOH 2014).

In the catchment area, latrines have been built in most villages but overall latrine coverage is low in areas close to the rivers, increasing the risk of water borne diseases such as cholera, typhoid, dysentery, diarrhea etc. whenever it rains or floods. The socio-economic survey assessed the

coverage of human excreta disposal facilities in the catchment area. The results indicate that the traditional pit latrine is the most commonly used facility of human waste disposal at 94.4% (Figure 3-10). Parts of town councils and Kapchorwa municipality were accessing flush toilets at 5.1% partly because these are urban settings saved by NWSC facilities.

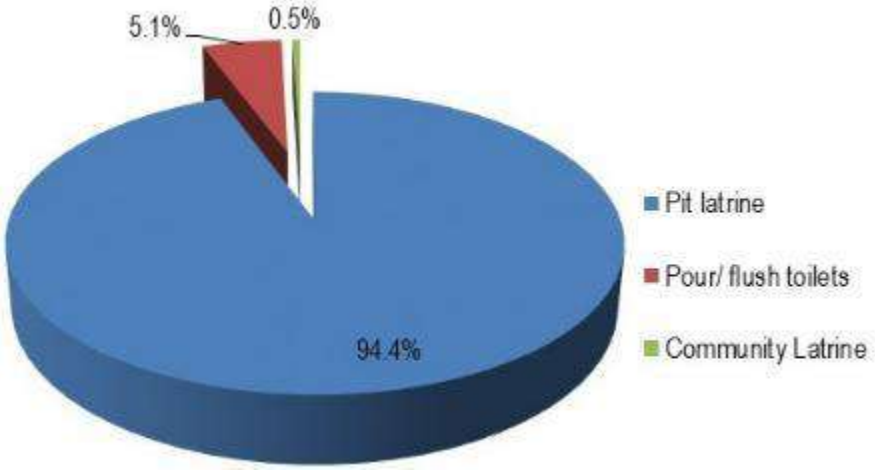


Figure 3-10: Type of facility of human waste disposal

Waste disposal methods/facilities

Household waste management has both environmental and health implications on individuals and communities. Improper disposal of waste could lead to proliferation of disease causing agents (pathogens) in the environment leading to disease outbreaks such as cholera, dysentery and typhoid, among others. The way households dispose of their solid waste can pose a risk to public health by attracting flies, mosquitoes as well as rats and rodents by allowing them to breed. This may encourage the spread of diarrhoeal diseases as well as other diseases.

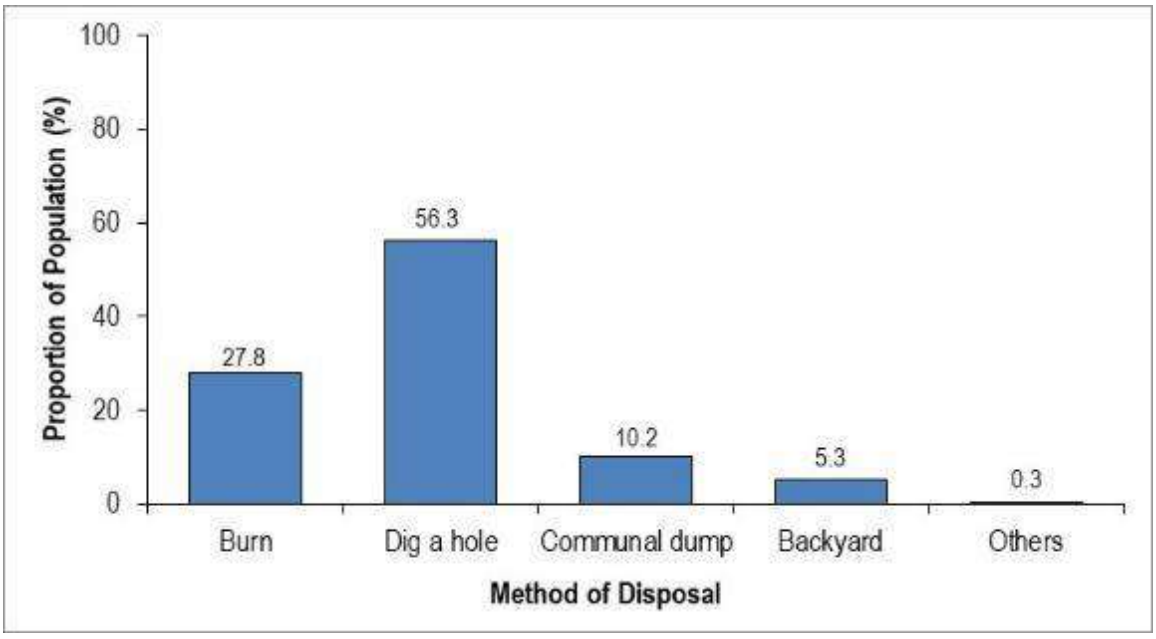


Figure 3-11: Solid waste disposal practices in the project area

3.2.4 Livelihood Strategies

Most households in Bulambuli and Kapchorwa District engage in subsistence agriculture where cultivation of both cash and food crops such as; coffee, bananas, beans, maize and ground nuts in addition to raring of livestock. Other economic activities include; trading, forestry, industry, tourism, metal works and fabrication, transportation, agro-processing, sand mining (mainly in Bulambuli and along river Sironko and its tributaries) and stone quarrying.

The main economic activity in the District is Agriculture service industry and trading The District is very productive in agricultural products and is a food basket to most of the Districts in Uganda. Most people in the district produce crops for commercial purposes and little is left for home consumption. Cash crops like coffee, Burley and wheat are purely for cash. The main crops grown are coffee, maize, beans, barley, wheat, matooke, Irish Potatoes, millet, Sun flower, cow peas and passion fruit. Other economic activities include agro-processing of mainly maize and coffee. Livestock farming – cows, sheep, goats, donkeys and pigs. Also poultry, bee keeping and eco - tourism among other economic activities are also practiced in the District. Vegetable growing has greatly increased with markets as far as Southern Sudan. They include Cabbages, Onions, Carrots, Tomatoes and Sukuma.

3.2.5 Proposed environmental interventions

The interventions or control measures being proposed here under focus on addressing the identified key issues with a specific bias towards biodiversity. The proposed actions are summarized below (Table 3-3).

Table 3-3: Causes of biodiversity threats in the Lower Muyembe Micro-catchment and proposed intervention measures

The Lower Muyembe Micro-catchment management challenge	Underlying Cause	Intervention/Control Measure
1. Sustainable land/ soil management challenge	Loss/degradation of wetland belt (due to agricultural encroachment) thus undermining capacity to filter sedimentation and or stabilize the river bank.	• Enforce wetland policy to protect or regulate wetland use and river banks. • Enforce Environmental Regulations (River banks and Wetlands). • Promote wise use practices of wetland resources. • Demarcate and protect Wetland/river bank protection zone. • Practice sustainable land management practices (terracing, grassing, mulching, agro-forestry) • Protect the remaining wetland pockets along the river course
2. Sustainable water management challenge	Poor waste management (from mines and irresponsible disposition of solid wastes)	• Improve capacity for safe handling and disposal of chemicals • Promote soils erosion control measures so as to reduce surface run off • Construct diversion trenches to trap and divert storm water or Soil wash from upstream
	Soil erosion/surface erosion from gardens and along the access road resulting in sedimentation/silting and pollution.	• Promote soils erosion control measures so as to reduce surface run off • Redesign road drainage and divert storm away from abstraction point. • Vegetate the river banks using bamboo • Promote agro-forestry within the catchment • Banana – coffee plantations which ensure that there is ground cover and less direct exposure to erosion
	Poor crop and livestock husbandry leading to contamination of water downstream	• Restrict human and livestock access activities in sensitive landscapes such as steep slopes, bare grounds • Ensure limited exposure of ground through mulching
3. Vegetation depletion in the catchment	Poor agricultural land uses in the catchment that affect tree cover	• Promote Sustainable land management /agricultural practices in the catchment. • Regulate wetland use upstream

The Lower Muyembe Micro-catchment management challenge	Underlying Cause	Intervention/Control Measure
		• Practice agroforestry • Practice cover cropping
	Declining tree /vegetation cover that increases direct exposure of land	• Increase tree cover through appropriate afforestation or agroforestry practices with appropriate tree species. • Maintain vegetation around river banks and within the catchment
4. Maintenance of river bank Infrastructure	Encroachment on the river buffer systems leading to fragile banks. Additionally, increased sediment load due to erosion and siltation	• Enhance river course stability though tree planting • Re-open the river courses / sediment removal • Stabilize River bank where appropriate using gabions • Revegetate the river banks using bamboos
5. Ensuring adequate and equitable access to wetland or river resources	Population growth or concentration along river course resulting into increasing demand on land resource and the resource therein	• Promote alternatives to required resources • Encourage more efficient systems such water harvesting /water storage technologies, energy saving cook stoves.
	Conflicts related to access water among current and potential water users (Big water users, industries, institutions and irrigation schemes)	• Engage Stakeholders in designing and monitoring the water supply system. • Discuss water use permits with the stakeholders • Develop and apply conflict mitigation/ management strategies.
6. Sustaining livelihoods challenges	Declining soil fertility and over-all land productivity	• Promote Sustainable Land Management practices (soil fertility management, control of soil loss, etc.) • Promote technologies for enhancing land productivity (e.g., improved varieties of crops, disease and pest control, etc.)
	Conflicting or competing land (e.g., cultivate wetland edge)	• Zone protection areas of the wetland, river and infrastructure • Empower stakeholders to plan for and manage their sub-catchment

The Lower Muyembe Micro-catchment management challenge	Underlying Cause	Intervention/Control Measure
	and water uses such as irrigation	• Increase awareness on the relationship between land/water management and the health of the catchment
7. Artisanal mining	Soil erosion, landslides, siltation, water contamination, sedimentation, infrastructural deterioration, ecosystem alteration and loss	• Controlled resource mining with mitigation plans. • Livelihood diversification
8. Motorcycle/motor vehicle washing bay	Water and air pollution, increased disease incidences, air pollution, sedimentation.	• Planned designated areas for washing bays.

Lower Muyembe Strategic Social and Environmental Assessment (SSEA) was a systematic, analytical, participatory and comprehensive process for evaluating both social and environmental consequences of proposed catchment management plan and intervention projects, initiatives and alternatives to ensure that they are appropriately addressed at the earliest stage of decision-making. This SSEA will be a useful tool in guiding future planning and developments within the catchment.

At the strategic level, this SSEA assessed:

d) The major social and environmental issues in the catchment today and potential issues are in the future that the plan should foresee hence attempt to mitigate, taking into account the resource base and development opportunities that stakeholders desire.
e) The cumulative impacts of water resources developments and use in the catchment up to today, and what could be potential future impacts.
f) The issues and impacts that may influence how well the catchment plan achieves the planning goals and objectives.

At one end, the focus was on impact analysis and sustainability and at the other, on institutional assessment. This was aimed at improving awareness of the nature and significance of social and environmental issues in the catchment resulting from land use and development activities, to help stakeholders understand the potential implications of these issues and cumulative impacts, and to integrate them into the planning process.

4 CATCHMENT WATER DEMAND

Water demand was estimated for irrigation, domestic water consumption and livestock consumption. The demand estimations were used to inform the water balance modelling at the scale of micro-catchments defined in each sub-catchment.

4.1 Domestic Water demand

Human water consumption was the primary focus of water demand in the micro-catchments and in accordance with policy, it has the highest allocative priority. To derive the water consumption water demand, it was necessary to get the population dependent on the water and their respective per capita water demand. The population statistics of 2024 was used as a basis for projecting population growth at an annual rate of 3.0%.

4.1.1 Main Hypothesis and Data

Consumption Rates per capita

The specific water consumption rates in the DWD Water Supply Design Manual 2013, were adopted in the estimation of water consumption rates. The national target was a basic provision of 20 liters per person per day, which is considered to be the minimum quantity of water a person needs to meet basic health requirements. The National Water Assessment Report estimated the consumption rate for rural and urban populations under current and future situation. The average total water demand in l/head/day from the NWRA were used to estimate the water supply demand in the micro-catchments.

Table 4-1: Estimated design consumption rates for rural and urban areas at present and projected to 2050 (Source: NWRA)

Parameter	Present		Future	
	Rural	Urban	Rural	Urban
Average domestic water demand (l/c/d)	20.4	36.0	20.8	44.8
Institutional water (% of domestic demand)	5	30	5	30
Average total water demand (l/c/d)	21.4	46.8	21.8	58.2

Water losses

The water consumption rates used in designing water supply facilities depend on the service levels and include a provision of **20% for water loss** through leakage and other wastage, as well as for flushing pipelines, storage tanks, and other internal water uses. Practically to limit leakages to 20% and maintaining such efficiency requires regular investment in maintenance which is sometimes difficult. However, this figure of 20% seems coherent with actually observed values in the catchment. This figure has been used to take into account losses for urban water supply. No losses have been considered for rural water supply.

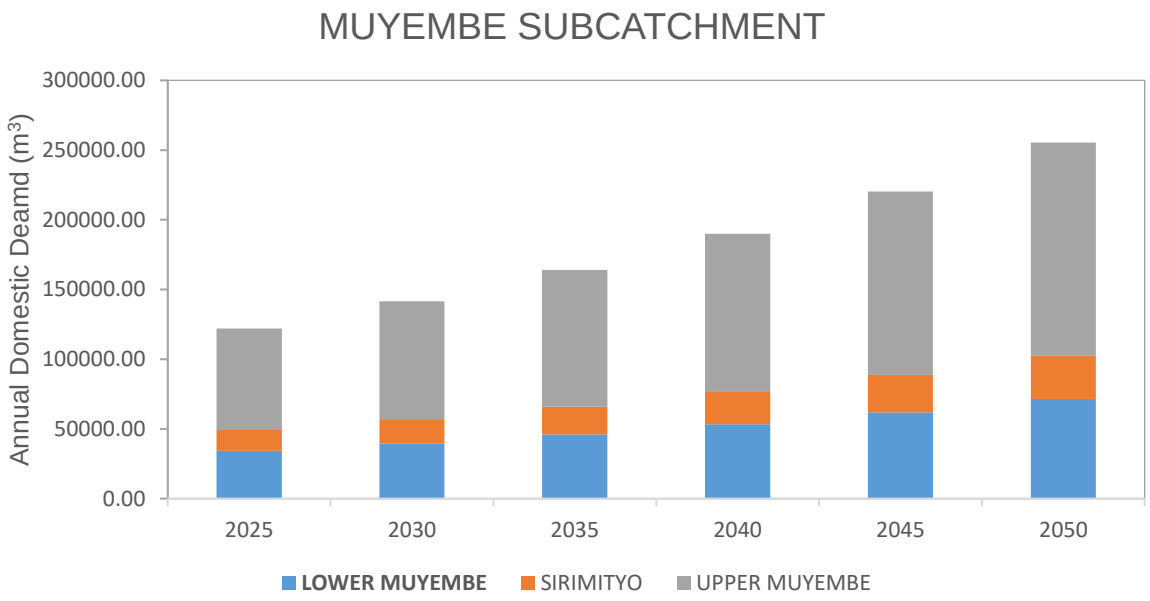


Figure 4-1: Domestic demand in Sironko Catchment

4.2 Irrigation Water Demand

Water demand for irrigation (Figure 4-3) was estimated basing on the cropland cover within the different micro-catchments and sub-catchments. Demand was based on unit water demand per sq. km (considering tomatoes as the design crop since it has the highest consumption rate during flowering), cropping pattern (Figure 4-2) as well as information about the techniques used for irrigation (gravity, aspersion, drip irrigation).

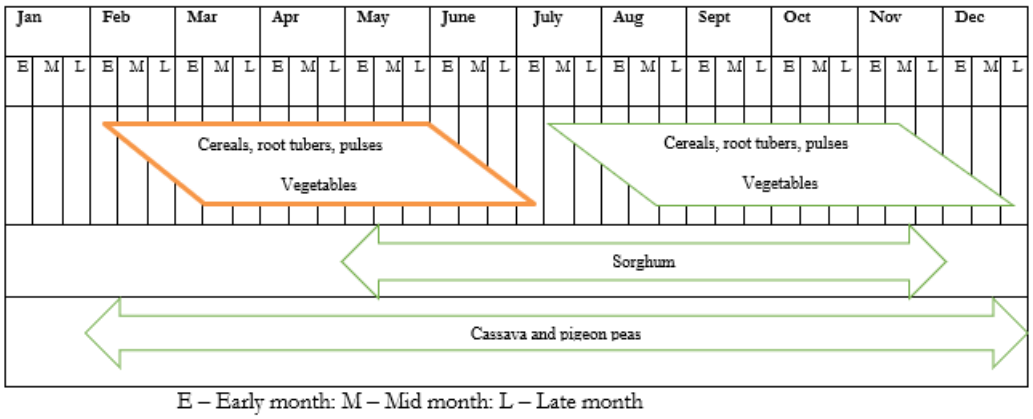


Figure 4-2: Cropping Pattern

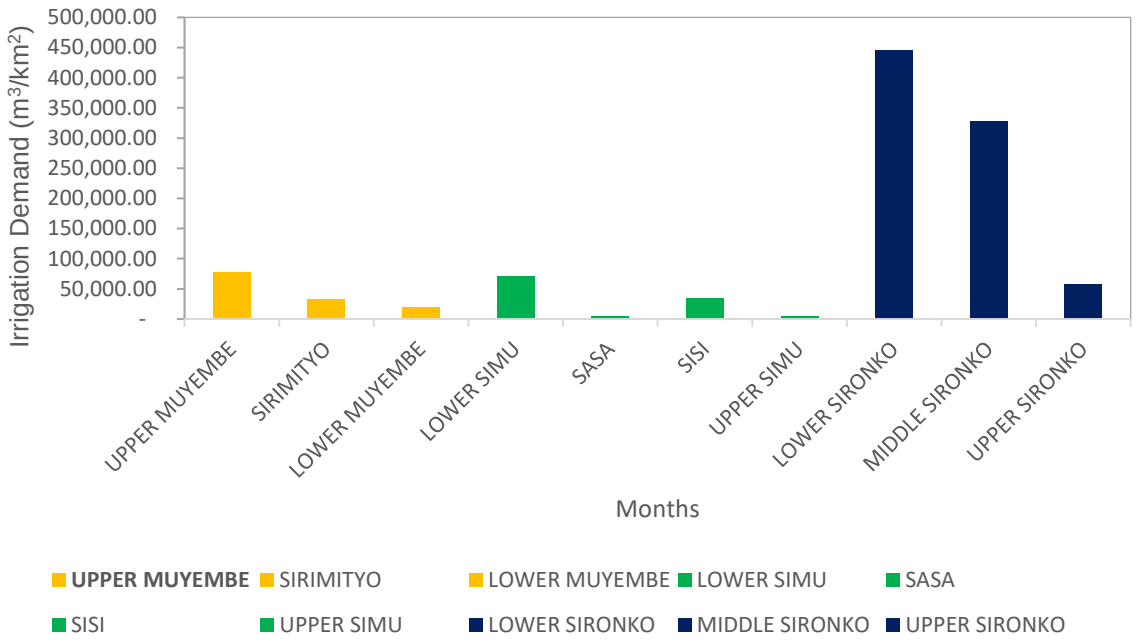


Figure 4-3: Irrigation water demand

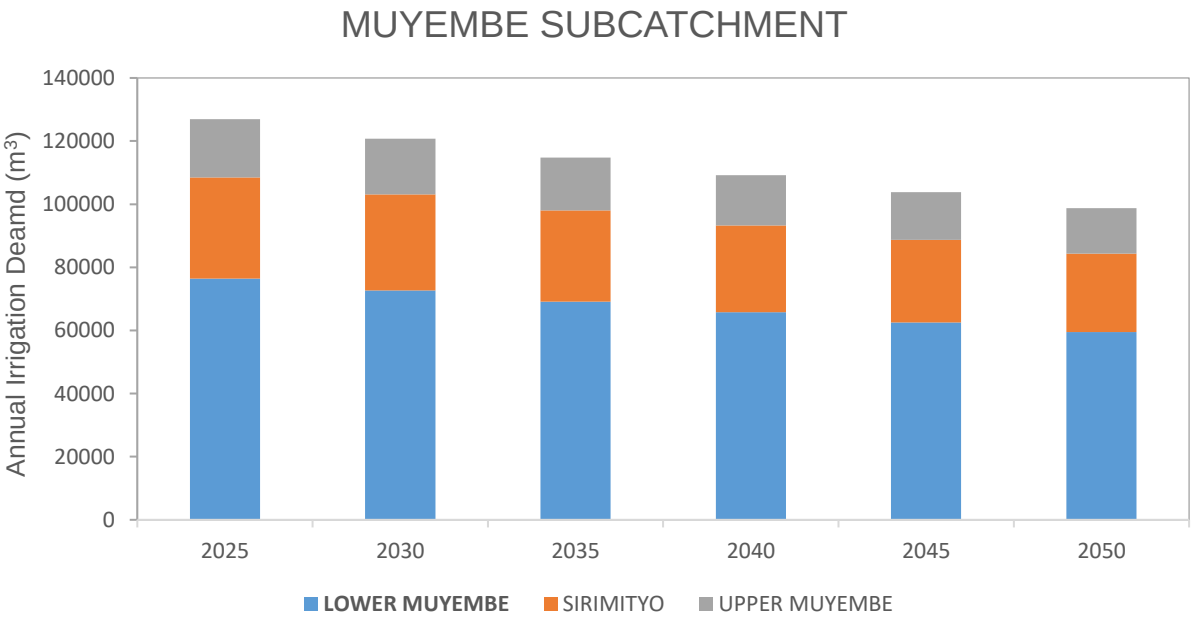


Figure 4-4: Annual irrigation water demand in Muyembe subcatchment

4.3 Livestock Demand

One of the uses made of water and which must be taken into account regarding the water balance was the consumption of water by livestock. In this section, the methodology applied to estimate the water demand for livestock and the obtained results are presented. The unit water demand figures for livestock were adopted from the Ministry of Water and Environment Water Supply Design Manual 3rd Edition.

Data used was extracted from “The national livestock census report, 2021” established and published in 2024 by the Ugandan Bureau of Statistics in estimation of the water demand. This census is the only one presenting data at district level. Due to the fact that the census has been realized in 2021, the estimate presented hereafter was realized using the district boundaries. Additionally, the following estimate of the water demand was realized for cattle, goat, sheep, pig and chicken. This choice can be explained by the data availability and the necessity to consider the representative types of livestock. As for the other type of water uses, the water demand for livestock was estimated at catchment basis in order to be included in the water demand – water resource model. The assumption was that livestock is distributed homogenously in a district. Figure 4-6 illustrates a summary of the water demand estimates within the micro-catchments defined for each sub-catchment. It is evident that the demand estimates increase downstream of the sub-catchments mainly attributed to the population proportion in the midstream and downstream micro-catchments.

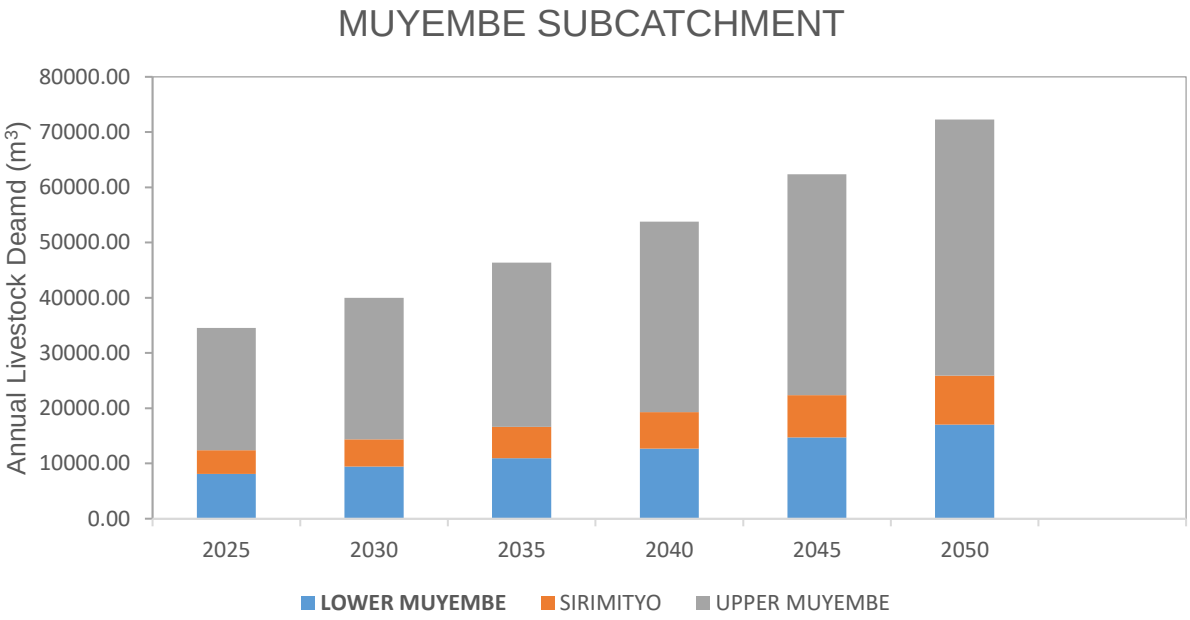


Figure 4-5: Livestock demand Muyembe sub-catchment

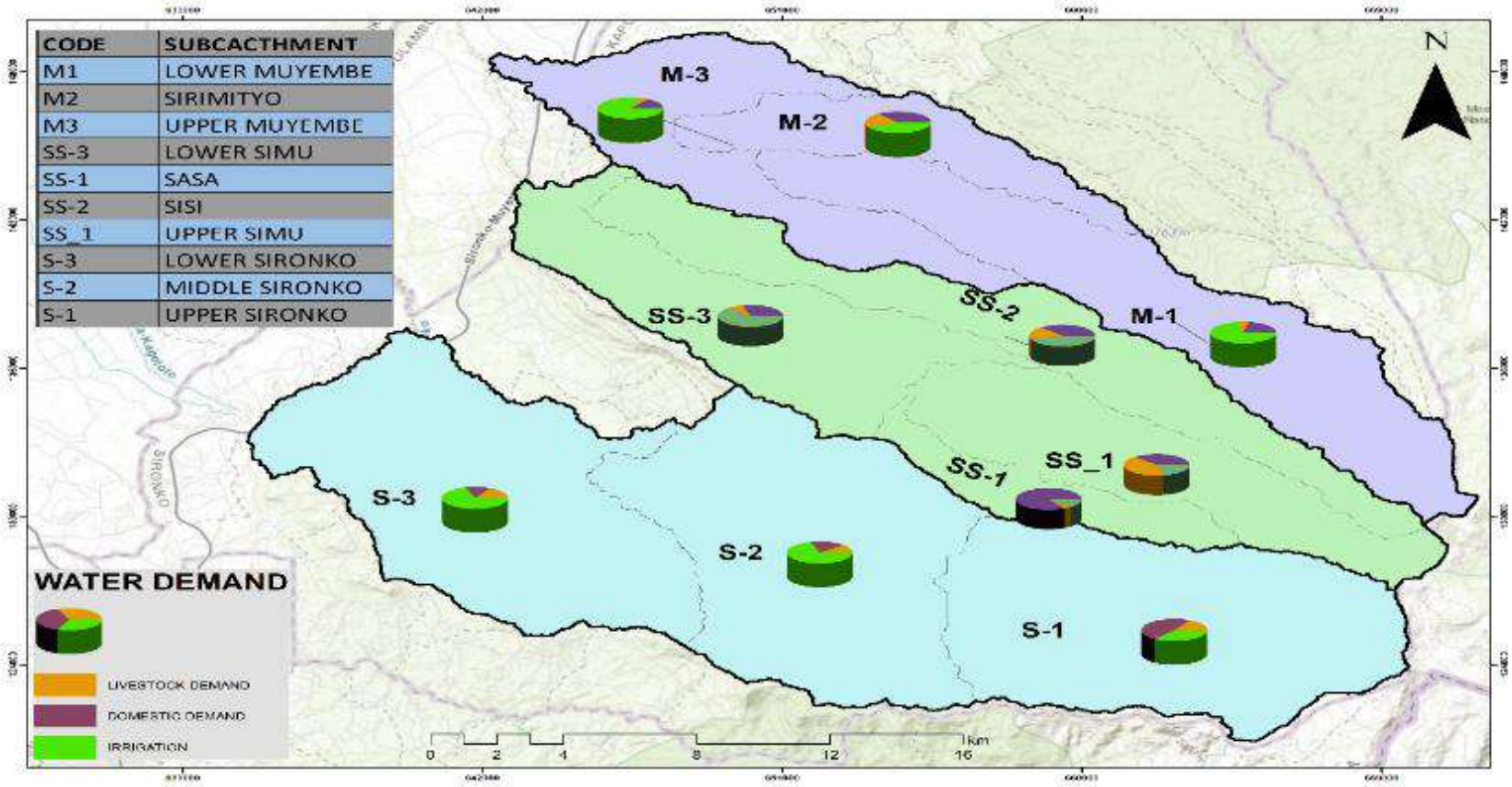


Figure 4-6: Summary of the water demand in the sub-catchments. (see M-1)

4.4 Industrial Demand

The current and future industrial water demand were estimated by considering only 1% of the domestic and livestock demands as vindicated in Table 4-2.

Table 4-2: Industrial water demand for Lower Muyembe subcatchment

Water Demand	YEAR					
	2025	2030	2035	2040	2045	2050
LOWER MUYEMBE						
Domestic Water Demand Scenario (m^3/year)	34,193	39,639	45,953	53,272	61,757	71,593
Livestock Water Demand Scenario (m^3/year)	8,134	9,429	10,931	12,672	14,690	17,030
Industrial Water Demand (m^3/year)	423.27	490.68	568.84	659.44	764.47	886.23
Total Demand	**42,750.27**	**49,558.68**	**57,452.84**	**66,603.44**	**77,211.47**	**89,509.23**

4.5 Demand allocation priorities

Demand Priorities allows the user to specify the order in which the water requirements of demand sites are satisfied and to be represented in WEAP water allocation as it actually occurs in their system. If two demand sites have the same priority, WEAP attempts to satisfy their water requirements equally. The quantity, timing, and reliability of supply is of great importance in water allocation while considering other competing water uses. Water allocation principles applied ensure equity, environmental protection, development priorities, as well as striking a balance between supply and demand so as to manage natural variability of water.

Based on these considerations and with regard to the water resources availability, as well as the water allocation principles stipulated in the National Water Policy, 1999, water was allocated as follows:

- The first priority was given to domestic water needs and environmental flow,
- Second priority was given to livestock, fisheries, and irrigated agriculture,
- Third priority was given to industries.

5 WATER RESOURCE ASSESSMENT

Hydro meteorological information is a key requirement during water resources assessment. This information could present serious deficiencies in quality and quantity, observing data with changes, lack of information, trends and outliers. This misrepresents the results of any simulation/ modelling. For correct use of hydro meteorological information, it must go through quality control and comply with the assumption of seasonality, consistency, and homogeneity.

5.1 Rainfall

5.1.1 Source of data

Three main sources of rainfall data have been examined:

Records of observed rainfall

Historical rainfall data measured at weather monitoring station managed by the Ugandan Meteorology Department (a few stations are also managed by DWRM). Data from the existing monitoring network (some of which are not operating anymore) have been looked at. In total data from three (3) rainfall stations in Elgon region was accessed for this study. However, the stations were not uniformly distributed in the sub-catchments. Similar observation has already been made at national level, during the NWRA, which provides a list of existing rainfall stations with long record sets of good quality data. This list includes only 3 stations in the area, among which only one is located within the sub-catchments.

Table 5-1: List of identified rainfall gauge stations

Eastings	Northings	Station Name	Start data	End date	Duration (yrs)
652089.5	141850.9	Buginyanya	01.01.2010	31.12.2024	14
648319.8	112439.8	Bududa Station	01.01.2010	31.12.2024	14
639083	112436.1	Sironko	01.01.2010	31.12.2024	14

Data from satellite

Satellite precipitation products have greatly facilitated the estimation of precipitation at global and regional scales, especially in areas with few surface rain gauges and poor performance of other traditional methods. Climate Hazards Center InfraRed Precipitation with Stations (CHIRPS) is a 30+ year quasi-global rainfall dataset (Table 5-2). CHIRPS incorporates 0.05° resolution satellite imagery with in-situ station data to create gridded rainfall time series for trend analysis and seasonal drought monitoring. This product has the advantage of including long periods of historical rainfall data based on observations (data are available from 2001 to date).

Table 5-2: List of identified satellite stations

Sub-catchment	Stations	UTME	UTMN	Duration (yrs)
Muyembe	ST-0	647413.4	146492	23
	ST-1	652977.2	146495	23
	ST-2	652980.2	140966.9	23

Sub-catchment	Stations	UTME	UTMN	Duration (yrs)
	ST-3	658544.3	140969.9	23
	ST-4	664111	135444.7	23

The use of an existing precipitation products such as CHIRPS has the following advantages:

a) They provide daily data on a long record period, (including over recent years) without gaps (consolidation of data and gap filling has already been carried out by way of a spatialized analysis).
b) Unlike manned stations, they have a better spatial distribution of precipitation within the micro-catchments

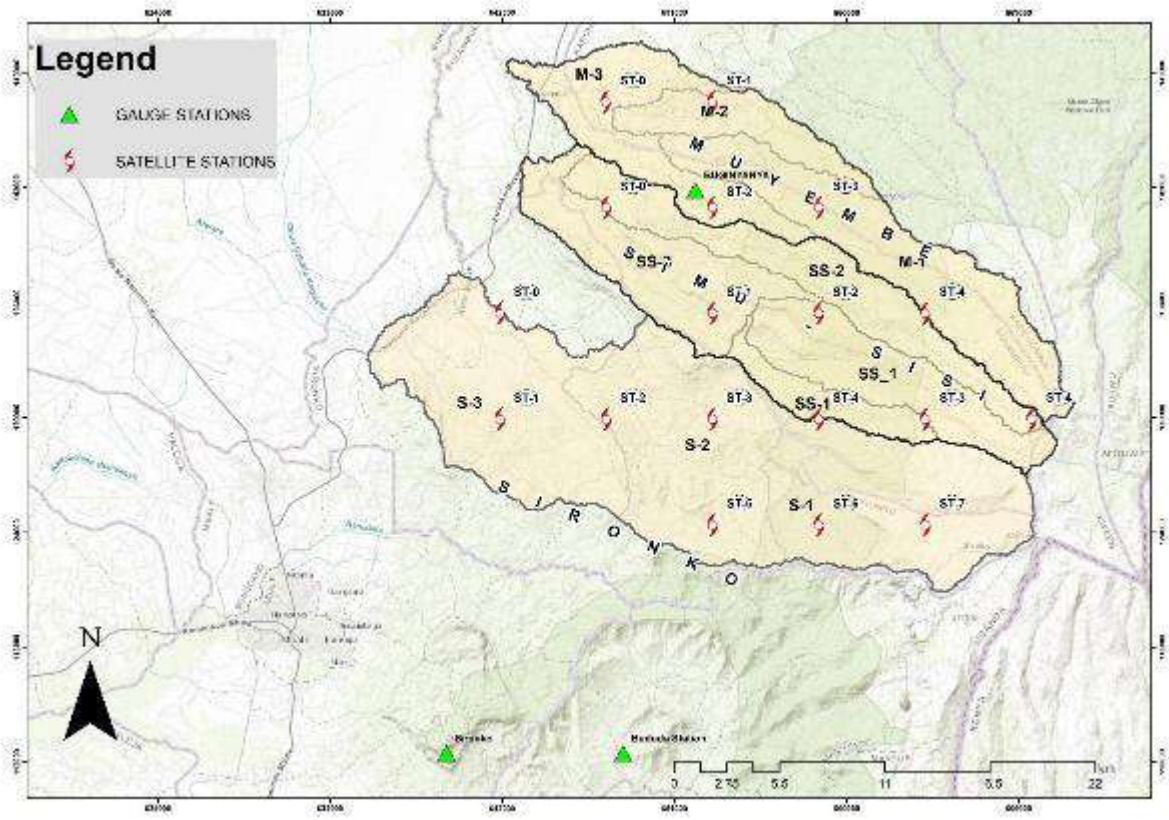


Figure 5-1: Location of weather stations

5.1.2 Relevance of Chirps precipitation products

The relevance of CHIRPS database was assessed in order to check if they could be used to represent the climate of micro-catchments. This was done by: (i) looking at the correlation between CHIRPS rainfall and rainfall from different observed stations, (ii) comparing average rainfall of CHIRPS and all the rainfall stations located in the corresponding thiessen polygon, and (iii) comparing the data CHIRPS data series and data series from some of the stations.

In order to assess which of the two satellite products best represents the rainfall on the catchment, two checks were performed. First, the correlations between monthly rainfall at different station and from the two databases have been compared, and correlation with CHIRPS proved to be the best (see Figure 5-2).

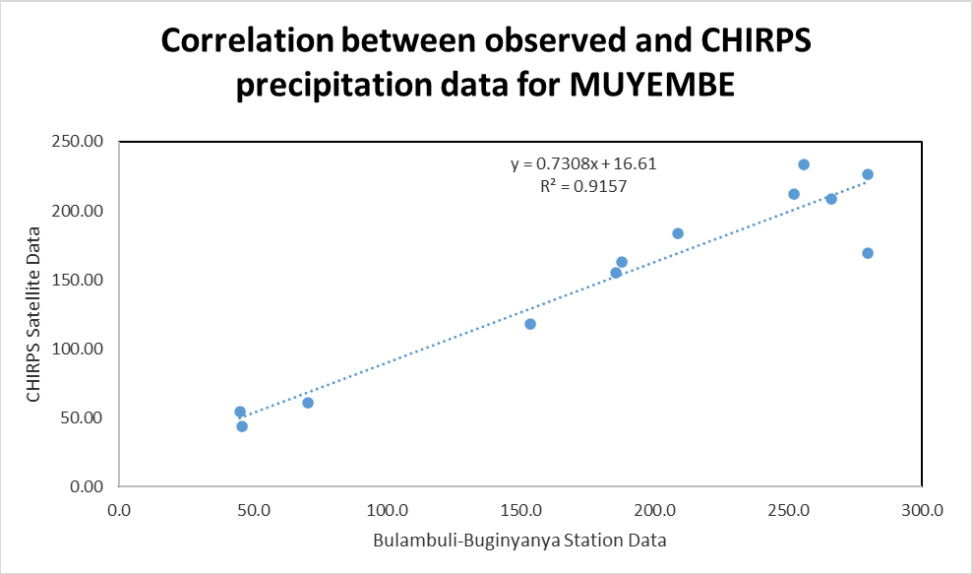


Figure 5-2: Correlation between rainfall measured at rainfall station and rainfall from CHIRPS datasets.

Therefore, data from CHIRPS seem better related with observed data since the correlation coefficient was above 0.6 as indicated in the GoF plots and thus were chosen for this study.

Conclusion

Rainfall data from CHIRPS seems fairly consistent with rainfall measured at stations. They can therefore be used to represent the rainfall of the catchment in subsequent analysis.

5.2 River flows

Hydrological data are the main material for surface water resources assessment, and water demand balance analysis following from it. Analysis of the flow data was therefore of primary importance. Doing such an analysis, one may also identify some of the causes explaining insufficient data quality (for example an outdated rating curve), and corrective measures can be taken to tackle these causes. Two gauging stations provided flow records in the sub-catchments, the immediate ones being 82240 and 812243.

Station ID	Eastings	Northings	Elevation	Station Name	Catchment Area km²	Start data	End date	Duration (years)
82240	639845.35	1366600.71	1112	R. Sironko at Mbale-Moroto Road	276.21	1.01.2015	31.12.2021	7
812243	646235.3	1528779.3	1078	SW-R. Sipi at Mbale - Moroto Road	87.26	1.01.2015	31.12.2023	9

Table 5-3 below summarizes the main characteristics of the flow records.

Table 5-3: Summary of flow records

Station	Overall quality of the gauging station	Available chronic length / Selected data for analysis	Remark
82240	Station presenting good and reliable periods of flow data useable for both statistical analysis and modelling. Some record periods have been excluded from the analysis as they proved unreliable.	Data available from 1.01.2015 - 31.12.2021, Selected data: Data is considered reliable for the water resources assessment in the WEAP model	Station located in Sironko sub-catchment. Suitable for modelling with a Catchment area of 276.21 km^2. Station was used to derive data for R. Simu since it was adjacent with similar catchment characteristics
812243	Station presenting good and reliable periods of flow data useable for both statistical analysis and modelling. Some record period have been excluded from the analysis as they proved unreliable.	Data available from 1.01.2015 - 31.12.2023, Selected data: Data is considered reliable for the water resources assessment in the WEAP model.	Station located in the adjacent sub-catchment next to Muyembe but was used with area prorata approach to derive flow data for R. Muyembe since it was adjacent with similar catchment characteristics

Precipitation was checked in order to see whether increase in low flows can be explained by an increase in precipitation. Both annual total and total rainfall from 2015 to 2021 have been calculated for the catchment upstream the gauging station 82240 and compared to the flows. As it is indicated on Figure 5-3 below, 2019 -2020 seem to have been wet years and ensuing into a wetter period between 2020. There seem to be lows for the period 2021 albeit increase in precipitation.

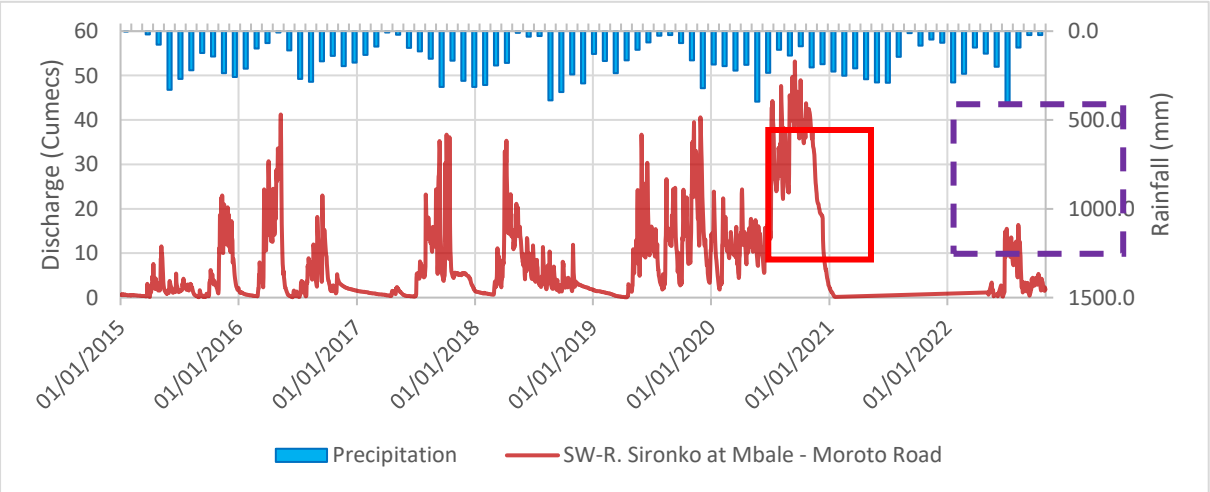


Figure 5-3: Annual rainfall and daily flows measured at station 82240

Precipitation was checked in order to see whether increase in low flows can be explained by an increase in precipitation. Both annual total and total rainfall from 2015 to 2021 have been calculated for the catchment upstream the gauging station 812243 and compared to the flows. As it is indicated on Figure 5-4, 2018 -2019 seem to have been wet years and ensuing into a wetter period between 2020. There seem to be lows for the period 2021-2023 albeit increase in precipitation.

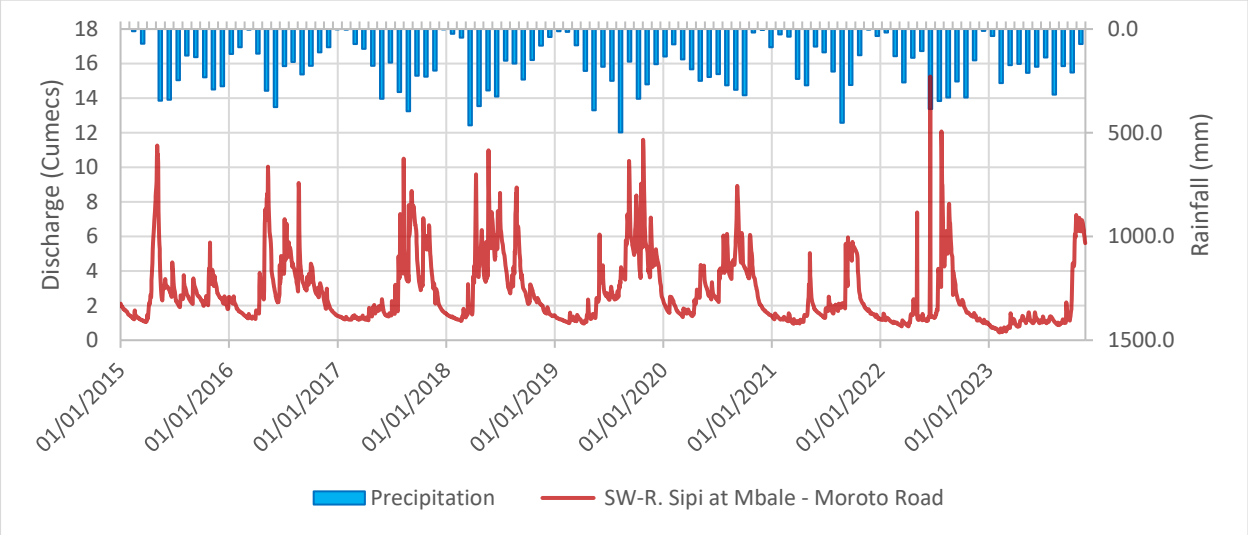


Figure 5-4: Annual rainfall and daily flows measured at station 812243

One possible explanation for this apparent paradox is that streamflow sensitivity to precipitation appears to be lowest for the high flows, suggesting that high flows are much less likely to exhibit precipitation induced trends than either low or average flows. Another possible hypothesis, is that trends in precipitation during the season of the high flows are significant when averaged over large areas, but not when averaged over the small spatial scales of individual basins. Still another hypothesis considered here is that precipitation may not have increased at the basin scale during the other seasons which explains why the high flows have not increased during that period.

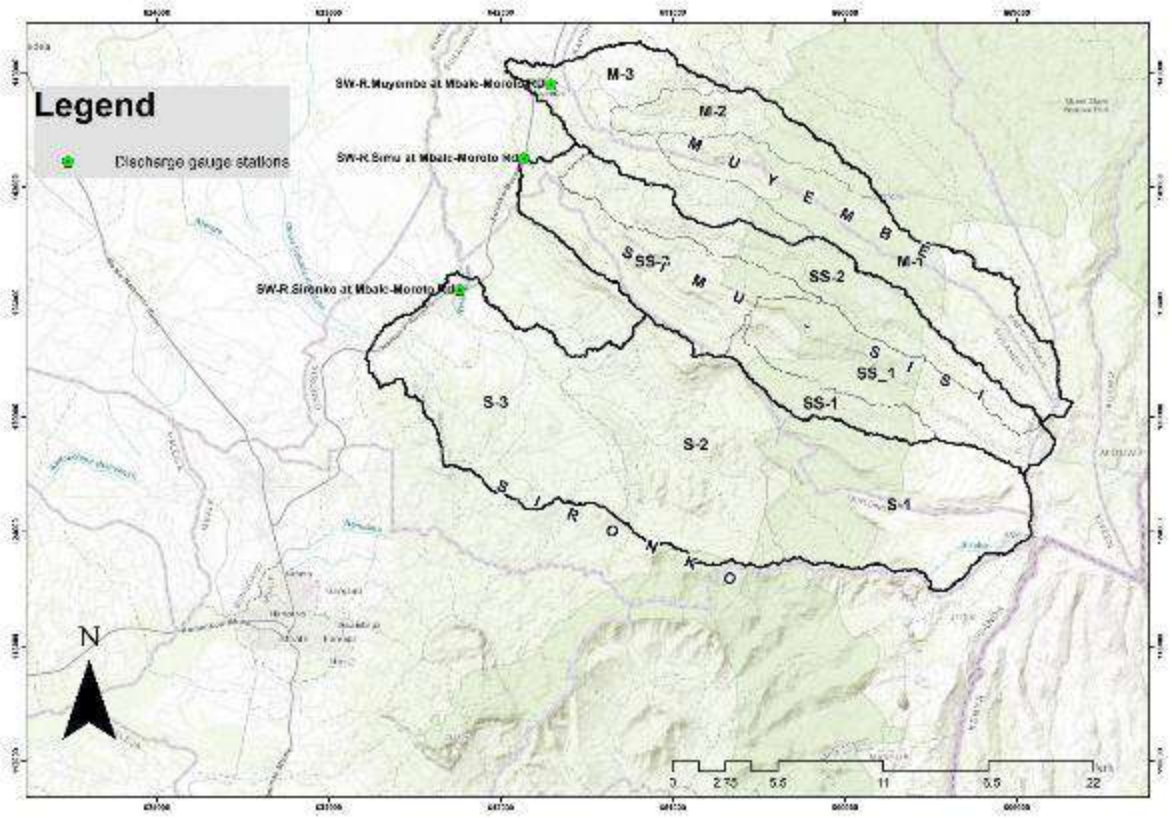


Figure 5-5: Location of discharge gauge stations

5.3 Available water

5.3.1 Surface water

Table 5-4 shows the current available surface water with the entire Simu-Sisi sub-catchment having a mean annual flow of 971.84 m^3/s or 2554.305 million cubic meters per year (MCM/Yr).

Table 5-4: Surface Water Availability for Muyembe subcatchment

Monthly Flows		m^3/s		
		MCM		
	Microcatchments			Subcatchment
	LOWER MUYEMBE	SIRIMITYO	UPPER MUYEMBE	MUYEMBE
Jan	14.734	7.987	22.591	45.311
	38.725	20.991	59.377	119.093
Feb	11.478	6.222	17.599	35.298
	30.167	16.353	46.255	92.775
Mar	12.704	6.887	19.479	39.070
	33.391	18.100	51.198	102.690
Apr	22.100	11.979	33.885	67.964
	58.085	31.486	89.062	178.633
May	32.102	17.401	49.222	98.725
	84.374	45.736	129.371	259.481

Monthly Flows		m^3/s		
		MCM		
	Microcatchments			Subcatchment
	LOWER MUYEMBE	SIRIMITYO	UPPER MUYEMBE	MUYEMBE
Jun	26.298	14.255	40.322	80.875
	69.119	37.467	105.980	212.566
Jul	31.868	17.275	48.863	98.005
	83.759	45.403	128.428	257.591
Aug	37.405	20.276	57.353	115.034
	98.313	53.292	150.744	302.349
Sept	39.879	21.617	61.146	122.642
	104.814	56.816	160.712	322.343
Oct	39.071	21.179	59.908	120.158
	102.692	55.666	157.458	315.816
Nov	29.193	15.825	44.762	89.779
	76.729	41.592	117.648	235.969
Dec	19.176	10.395	29.402	58.973
	50.400	27.320	77.279	155.000
Annual (MCM)	830.568	450.224	1273.513	2554.305
Annual (m^3/s)	316.006	171.296	484.532	971.835

5.3.2 Groundwater availability

Since groundwater generally requires less intensive and expensive treatment than surface water, it is a potential source of domestic water supply in most rural and urban areas.

5.3.2.1 Lower Muyembe Micro-catchment

The assessment of exploitable groundwater quantity in the Muyembe sub-catchment only considered the renewable groundwater resource. The renewable resource is the resource that can be replenished on average each year. Groundwater exploitation beyond the renewable resource is considered to be unsustainable. Due to the limited groundwater information in the subcatchment, relatively simple approaches such as recharge and base flow estimates were used to quantify the groundwater resources.

Based on the recharge estimates, the long-term monthly groundwater potential for each of the Muyembe micro-catchments is indicated in Table 5-5. The total groundwater storage for the entire Muyembe subcatchment was 37.72 MCM/year (Table 5-6).

Table 5-5: Long-term monthly groundwater potential per sub-catchment based on recharge estimates in Muyembe subcatchment

Months	Micro-catchments			Muyembe Subcatchment (MCM)
	Lower Muyembe (MCM)	Sirimityo (MCM)	Upper Muyembe (MCM)	
Jan	1.985	1.955	1.913	5.852
Feb	1.793	1.765	1.728	5.286
Mar	1.985	1.955	1.913	5.852
Apr	1.921	1.891	1.851	5.664
May	1.985	1.955	1.913	5.852

Months	Micro-catchments			Muyembe Subcatchment (MCM)
	Lower Muyembe (MCM)	Sirimityo (MCM)	Upper Muyembe (MCM)	
Jun	1.921	1.891	1.851	5.664
Jul	1.985	1.955	1.913	5.852
Aug	1.985	1.955	1.913	5.852
Sep	1.921	1.891	1.851	5.664
Oct	1.985	1.955	1.913	5.852
Nov	1.921	1.891	1.851	5.664
Dec	1.985	1.955	1.913	5.852
Average	1.947	1.918	1.877	5.742

Table 5-6: Total groundwater storage in Lower Muyembe Micro-catchment

Microcatchment	Area (km^2)	Groundwater Potential (MCM/yr)	Groundwater Potential (m^3/s)
Lower Muyembe	49.063	12.266	0.389

5.4 Water Quality

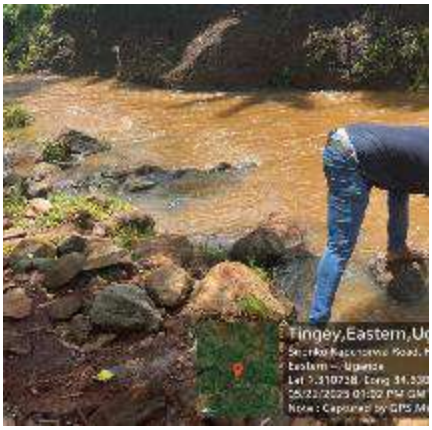
The water quality (Table 5-7) was substantially in compliance with the national standards for raw water quality albeit a few exceptions like color. This implies that with intentional intensified catchment management measures and post restoration periodic monitoring, good water quality shall be ensured in all the subcatchments.

Table 5-7: Laboratory water quality results

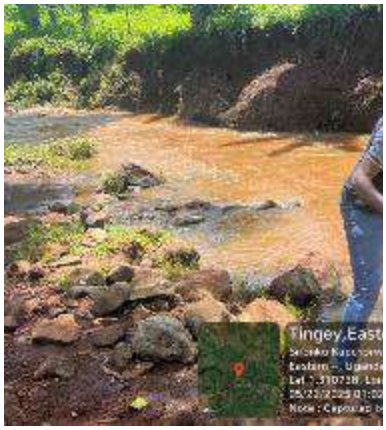
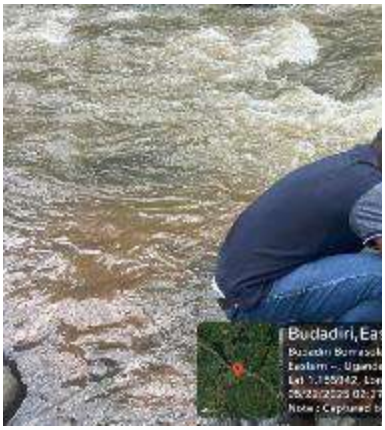
Source		Mid Sironko	Lower Sironko	Upper Sironko	Mid Sironko
District		Sironko	Bulambuli	Sironko	Sironko
UTME	m	191172	236052	151470	155940
UTMN	m	316849	257249	368752	361271
pH	pH units	8.1	8.2	8.2	8.1
EC	ms/cm	271	181	269	112
TDS	mg/l	190	127	188	78
Color	PtCo	289	2650	355	171
Turbidity (NTU)	NTU	49.1	177	48	28.7
Total Hardness as CaCO3	mg/l	125	93	115	71
Calcium Hardness as CaCO3	mg/l	80	64	95	34
Magnesium Hardness as $CaCO_3$	mg/l	45	29	20	37
Calcium	mg/l	32	26	38	14
Magnesium	mg/l	11	7	5	9
Total Alkalinity	mg/l	150	95	135	58
Bicarbonates	mg/l	183	116	165	71
Sodium	mg/l	14.8	7	12.6	2.6
Total Nitrogen	mg/l	1.223	1.424	2.306	1.362

Source		Mid Sironko	Lower Sironko	Upper Sironko	Mid Sironko
District		Sironko	Bulambuli	Sironko	Sironko
Total Phosphorous	mg/l	0.15	0.28	0.21	0.11
Aluminium	mg/l	0.311	5.515	0.593	0.214
Nitrates as N	mg/l	1.006	1.21	1.831	0.088
Nitrites as N	mg/l	0.027	0.015	0.011	0.008
Total Suspended Solids	mg/l	34	128	40	17








5.5 Climate change Analysis

In fulfilment of Article 4 of the Paris Agreement, Uganda launched the updating process of her first NDC in pursuance of paragraph 24 of Decision 1/CP.21 of the United Nations Framework Convention on Climate Change (UNFCCC) under the leadership of the Climate Change Department, Ministry of Water and Environment. In the updated NDC, Uganda presented an ambitious economy-wide mitigation target in 2030 of 24.7% reduction below the Business As Usual (BAU), a progression from the 22% reduction target communicated in the first NDC in 2016. Results from the Risk and Vulnerability Assessment conducted indicated that both ***temperature*** and ***rainfall*** are expected to increase in Uganda. However, there is still a wide range of possible scenarios and uncertainty, particularly for rainfall. The assessment revealed further that the priority sectors for adaptation in Uganda remain: ecosystem, water, agriculture, and forestry. These were also identified as priority sectors in the initial NDC.

The mitigation component presents Uganda's emissions profile, which is projected to increase from 90.1 $MtCO_2e$ in 2015 to 148.8 $MtCO_2e$ in 2030 and 235.7 $MtCO_2e$ by 2050 under the Business-As-Usual (BAU) Scenario. Uganda plans to implement policies and measures in the Agriculture Forestry and other land uses (AFOLU), energy, waste, transport, and IPPU sectors that will result in a 24.7% reduction of national GHG emissions below the BAU trajectory in 2030, to 112.1 $MtCO_2e$. 82.7% of the mitigation impact will come from the AFOLU sector, while 7.56%, 6.36%, 3%, and 0.4% will come from the transport, energy, waste, and Industrial Processes and Product Use (IPPU) sectors, respectively. The total cost of implementing adaptation, mitigation, coordination, monitoring, and reporting of this updated NDC is estimated at USD 28.1 billion. Uganda commits to mobilize domestic resources to cover the unconditional actions to the tune of USD 4.1 billion equivalent to 15% of the total cost of the updated NDC and will require international support to cover the conditional measures and actions.

Climate change impacts at local to regional scales are essential in enhancement of public understanding of possible future global climate patterns at the spatial scale of individual towns, cities, and catchments. The NASA Earth Exchange Global Daily Downscaled Projections (NEX-GDDP) dataset is provided to assist agencies in climate projections. The Coupled Model Intercomparison Project Phase 6 (CMIP6) GCM runs were developed in support of the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR5). A stark contrast between the CMIP5 & CMIP6 is that CMIP5 data entails Representative Concentration Pathways (RCPs) such as RCP2.6, RCP4.5, RCP6.0 and RCP8.5 whereas CMIP6 uses Shared Socioeconomic Pathways (SSPs), including SSP 1-1.9, SSP1-2.6, SSP2-4.5, SSP4-6.0, and SSP5-8.5. Specifically, RCPs are a set of scenarios for greenhouse gas concentration trajectories, while SSPs are broader scenarios that combine socioeconomic development narratives with these emissions pathways and they are combined into a matrix to force existing GCMs like ACCESS-CM2, CanESM5, GFDL-CM4, MPI-ESM1-2-LR to generate climate projections for different future pathways.

NEX-GDDP-CMIP6 archive contains downscaled historical and future projections for 1950–2100 based on output from Phase 6 of the Climate Model Intercomparison Project (CMIP6). The downscaled products were produced using a daily variant of the monthly bias

correction/spatial disaggregation (BCSD) method and are at 1/4-degree horizontal resolution. Currently, eight variables from five CMIP6 experiments (historical, SSP1-2.6, SSP2-4.5, SSP3-7.0, and SSP5-8.5) are provided as procurable from 35 global climate models (GCMs). Each of the climate projections includes daily maximum temperature, minimum temperature, and precipitation for the periods from 1950 through 2100. The spatial resolution of the dataset is 0.25 degrees (~25 km x 25 km). Each of the climate projections includes monthly averaged maximum temperature, minimum temperature, and precipitation for the periods from 1950 through 2005 (***Retrospective Run***) and from 2006 to 2099 (***Prospective Run***).

Two Shared Socioeconomic Pathways Scenarios (SSP), considered under this assessment and consistent with IPCC-AR6, were a combination of SSP 2, SSP 5, RCP 4.5, and RCP 8.5. The SSP scenarios chosen were SSP 2-4.5 and SSP5-8.5 and are described as follows.

SSP1 assumes that: "relatively good progress is made towards sustainability, with sustained efforts to achieve development goals, while reducing resource intensity and fossil fuel dependency. There is rapid development of low-income countries, a reduction of inequality (globally and within economies), rapid technology development, and a high level of awareness regarding environmental degradation. The world is characterized by an open, globalized economy, with relatively rapid technological change."

SSP5 stresses conventional development oriented toward economic growth as the solution to social and economic problems through the pursuit of enlightened self-interest. The preference for rapid conventional development leads to an energy system dominated by fossil fuels, resulting in high GHG emissions and challenges to mitigation.

RCP 4.5 is associated with a +4.5 $W.m^{-2}$ radiative forcing (≈553 ppm CO_2) in 2100.

RCP 8.5 is a more extreme concentration pathway, which is associated with a +8.5 $W.m^{-2}$ radiative forcing (≈1284 ppm CO_2) in 2100. The national temperature and precipitation for Uganda as per the considered scenarios are summarized in Table 5-13 below.

SSP2-4.5 The intermediate GHG emissions scenario has CO_2 emissions remaining around current levels until the middle of the century (2050). The scenario projects a long-term global average warming of around 2.1°C – 3.0°C by 2100 compared to pre-industrial levels (1850–1900 baseline). The scenario sees global surface temperature increasing by approximately 1.5°C - 1.6°C in the near term (2021-2040) and 2.0°C by the mid-term (2041-2060).

SSP5-8.5 High and very high GHG emissions scenario SSP5-8.5 has CO_2 emissions that roughly double from current levels by 2050. The global average surface temperature is projected to increase by a very likely range of 3.3°C to 5.7°C by 2100, compared to the 1850-1900 baseline. While specific minimum and maximum temperature figures vary by region and time period, the overall trend is a significant rise in both, with some localized studies showing specific increases of 3.52°C to 7.70°C for daily wet-bulb globe temperature (WBGT) in some regions.

Canadian Centre for Climate Modelling and Analysis, Environment and Climate Change Canada, Victoria, Canada (CanESM5) model was chosen based on its ability and reliability to simulate rainfall over Uganda.

5.5.1 Monthly annual cycle

Based on CMIP6 models, all the sub-catchments are likely to experience an overall increase in the annual precipitation by end of the century under SSP 5-8.5 specifically in August, along with a likely rise in the frequency and intensity of extreme rainfall events.as shown in Figure 5-6. However, there are significant seasonal and spatial variations, particularly concerning the two main rainy seasons. The changes in precipitation in a warming catchment will most likely not be uniform. Adaptation can substantially reduce the risks of climate change impacts, but greater rates and magnitude of climate change increase the likelihood of exceeding adaptation limits (*high confidence*). The potential for adaptation, as well as constraints and limits to adaptation, varies among sectors, regions, communities and ecosystems. The scope for adaptation changes over time and is closely linked to socio-economic development pathways and circumstances

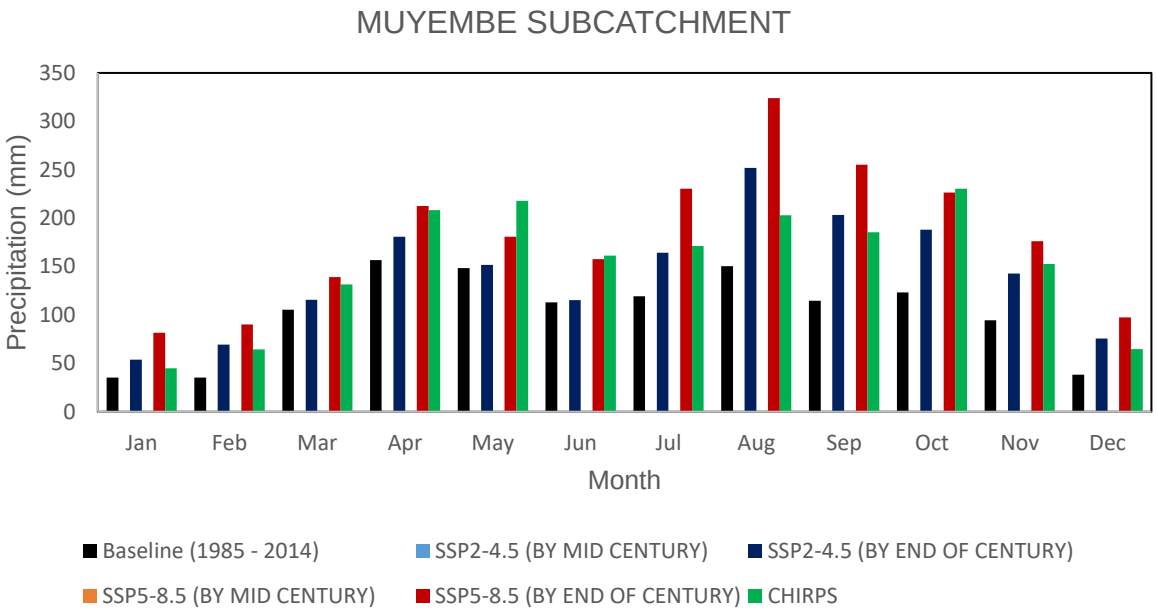


Figure 5-6: Monthly precipitation over Muyembe subcatchment based on CHIRPS, baseline (1985-2014), and for the GCM-CanESM5 projected period of 2026–2050, 2050–2100 under the SSP 2–4.5 and 5–8.5 emission scenarios

Table 5-8: Key projections by season

Season	**By Mid Century (2015-2050)**	**By End of Century (2051-2100)**
MAM (March-April-May, 'short rains')	Initial decreasing trend, with potential for significant decline in the short term under certain scenarios.	Significant increase projected, especially under high-emission scenarios (SSP5-8.5).

AON (August-September-October-November, 'long rains')	Wetter conditions projected under all emission scenarios and timelines.	Increasing trend is expected to continue throughout the projection period.
Annual	Overall annual precipitation is projected to increase across all microcatchment.	Significant overall annual increase, particularly under high-emission scenarios.

Spatial and Intensity Changes

- **Spatial Variability**: Rainfall changes will be unevenly distributed. The upper microcatchments are projected to see a more pronounced increase in rainfall.
- **Extreme Events**: There is a high likelihood of increased intensity and frequency of extreme rainfall events (e.g., very heavy precipitation days) across most micro-catchments. This suggests an increased risk of floods, even in regions where mean rainfall might decrease in certain seasons. Conversely, the analysis also projects a rise in the number of consecutive dry days in lower micro-catchments, particularly in Muyembe, increasing the risk of drought.

5.6 Vulnerability to extreme events

5.6.1 Flooding

Uganda experiences both flash and slow onset floods. They are common in low lying areas and areas along river banks and close to wetlands. They may also occur along lakes or more permanent wetland shores lower in the basin when El Nino episodes led to strong water level increase as in 1997-98.

Foothills of Mount Elgon are the most flood prone areas in eastern Uganda. The EM-DAT disaster database (EM-DAT 2025) indicates high risks of flooding associated with land and mud slides. in the three sub-catchments. In the EM-DAT disaster database, three flood events have been registered since 2011 in Bulambuli, Sironko, Kween, and Kapchorwa districts: 20/Aug/2011 – 08/Sept/2011; 08/May/2020 – 08/May/2020; 17/Sept/2021 – 22/Sept/2021. The event of 2020 is estimated to have affected more than 100,000 people country wide whereas for 2021, it is estimated that over 597 households were displaced.

Flood inundation extents and depths (Table 5-9, Figure 5-7, Figure 5-8, and Figure 5-9) for Kyoga basin were obtained using the global river flood hazard maps, gridded data sets representing inundation along the river network, for seven different flood return periods (10 year ARI to 500 years ARI).

Table 5-9: Mode depth for different return periods

Return Period	**Mode Depth (m)**	**Range (m)**
100 yr ARI	1	0.063 – 10.125
25 yr ARI	1	0.063 – 9.25
10 yr ARI	1	0.063 – 8.75

Figure 5-7: Flood depth of 100 yr ARI

Figure 5-8: Flood depth of 25 yr ARI

Figure 5-9: Flood depth of 10 yr ARI

5.6.1.1 Peak flows

The flood frequency analyses were aimed at estimating high discharges that ought to be taken into account to ensure that the interventions are not damaged by floods. Events for returns periods of interest even beyond the observed period of record were extracted with the assumption that future probabilities of exceedance will be the same as past probabilities to facilitate assessment.

For the baseline scenario, Table 5-10 indicate the flood magnitudes at the corresponding return periods for the microcatchment outlet. It is clear in all the cases that the peak flows associated to flood risks increase with the increasing return periods. The maximum observed flow of 4.95 m^3/s had a corresponding return period of 25 years which implies a substantially frequent risk of flooding downstream. The peak flows were also attributed to interflows and the antecedent soil moisture which consequently increases the flood inundation extents.

Table 5-10: Peak flows within Lower muyembe microcatchment

Annual Recurrence Interval (years)	**2**	**5**	**10**	**25**	**50**	**100**	**200**	**500**
Peak flows (m^3/s)	3.131	3.943	4.422	4.846	5.356	5.715	6.057	6.488

5.6.1.2 Low flows

For the same baseline scenario, Table 5-11 indicate low flow magnitudes with their corresponding return periods. The results also indicated that higher low flows are less likely to be experienced in the microcatchment. This can be attributed to effluence of the river within the microcatchment and higher base flow values associated to the shape of the microcatchment up to downstream areas.

Table 5-11: Low flows within Lower muyembe microcatchment

Annual Recurrence Interval (years)	**2**	**5**	**10**	**25**	**50**	**100**	**200**	**500**
Low flows (m^3/s)	0.330	0.400	0.421	0.434	0.439	0.441	0.442	0.443

5.6.2 Drought

Drought maps (Figure 5-11) for the sub-catchments were derived from vegetation condition index (VCI) of the Normalized Difference Vegetation Index (NDVI) vegetation layer. This index was first suggested by Kogan (1995 and 1997). It shows, effectively, how close the current month's NDVI is to the minimum NDVI calculated from the long-term record of remote sensing images.

$$VCI_i = \left(\frac{NDVI_i - NDVI_{min}}{NDVI_{max} - NDVI_{min}}\right) \times 100$$

As shown inFigure 5-10, about 99.7% of the sub-catchment area indicated an optimal or above-normal conditions. At the VCI value of 100% the NDVI value for this month (or week) is equal to NDVImax. Only 0.3% of the area experiences light drought conditions in Lower Muyembe micro-catchment.

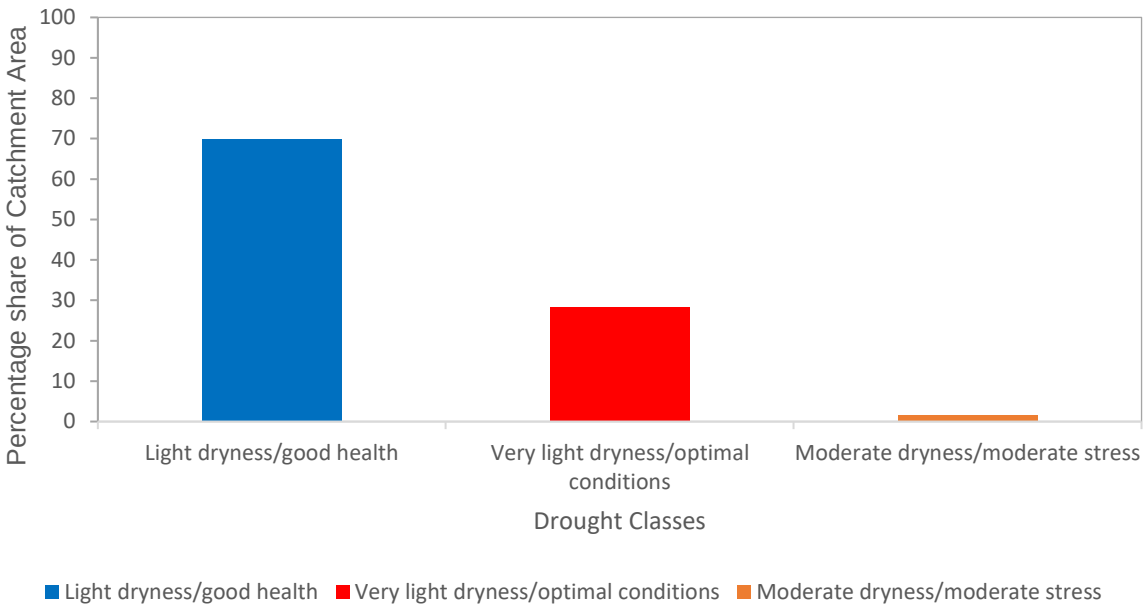


Figure 5-10: Drought class distribution across Lower Muyembe micro-catchment

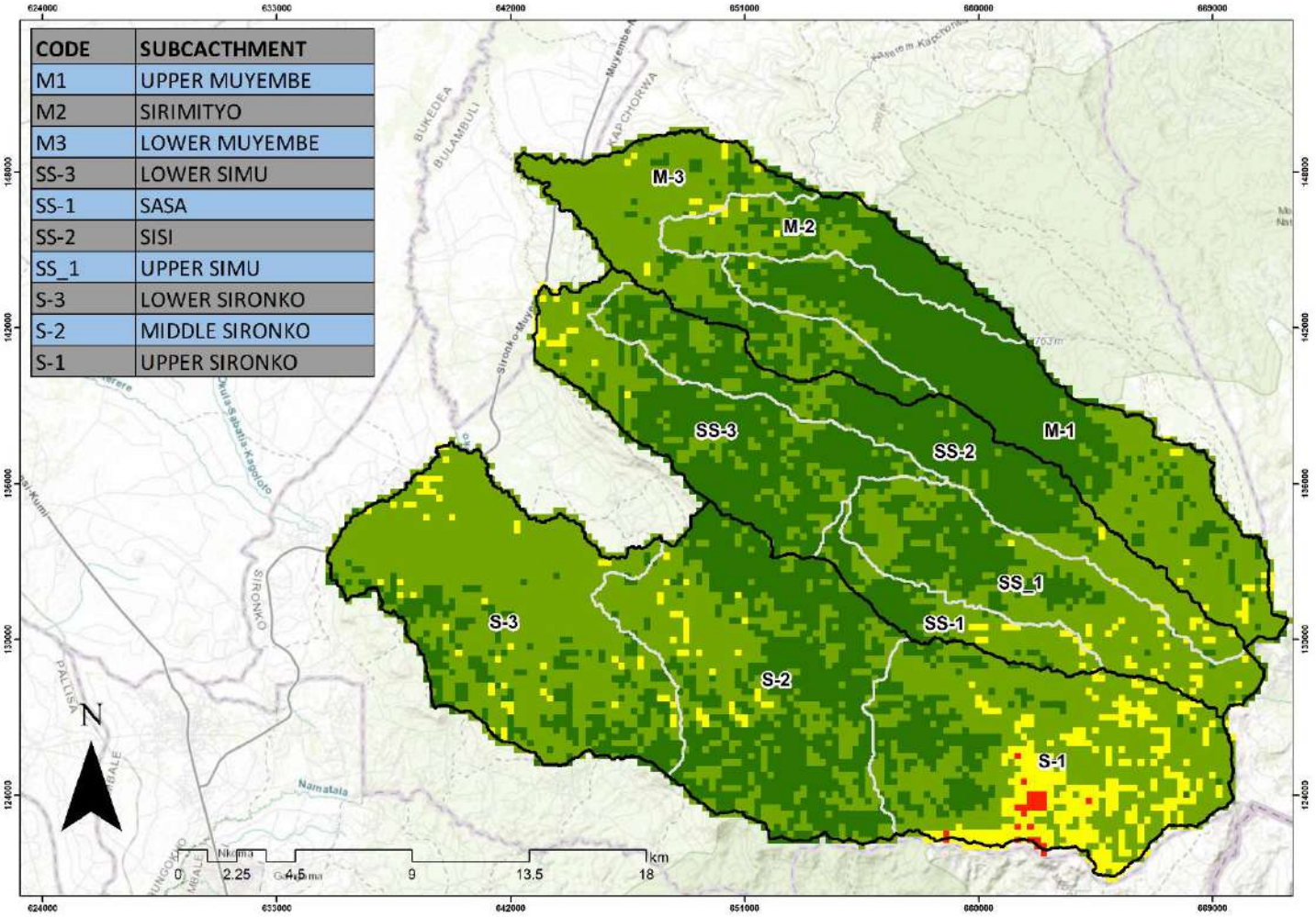


Figure 5-11: Drought distribution across Sub-catchments (see M-1)

5.6.3 Climate Change scenarios

Table 5-12 indicates the flood magnitudes for the baseline and different climate change scenarios at the corresponding return periods. The peak flows associated to flood risks are higher for the climate change scenario compared to the baseline scenario, implying that climate change will increase the vulnerability of the micro-catchment to flooding risks by mid-century (2050) and end of century (2100). In comparison to the baseline scenario, the peak flows will increase by an average of about 13%, 30%, 39%, and 76% for the climate change emission scenarios SSP2-4.5 (by mid-century), SSP5-8.5 (by mid-century), SSP2-4.5 (by end of century), and SSP5-8.5 (by end of century), respectively. The results further indicate that the climate change high emission scenario (SSP5-8.5) will have higher impacts than the climate change moderate emission scenario (SSP2-4.5).

Table 5-12: Comparison of flood magnitudes for the confluence of lower muyembe under the baseline and climate change scenarios

Annual Recurrence Interval (years)	**2**	**5**	**10**	**25**	**50**	**100**	**200**	**500**
Peak Flows - SSP2-4.5 (by mid-century) (m^3/s)	3.53	4.45	4.99	5.47	6.05	6.45	6.84	7.32
Peak Flows - SSP5-8.5 (by mid-century) (m^3/s)	4.08	5.14	5.76	6.32	6.98	7.45	7.89	8.46
Peak Flows - SSP2-4.5 (by end of century) (m^3/s)	4.34	5.47	6.13	6.72	7.43	7.93	8.40	9.00
Peak Flows - SSP5-8.5 (by end of century) (m^3/s)	5.51	6.93	7.78	8.52	9.42	10.05	10.65	11.41

5.7 Hydrological water balance

5.7.1 Overall Methodology

The surface water resources assessment was undertaken through different steps:

a) Data analysis: The primary data used for the water balance are mainly rainfall, evapotranspiration and flows. Data analysis is important in order to understand the results, interpret them and be aware of the level of accuracy and uncertainty of the assessment. Data have been carefully scrutinized.

b) Estimation of the available water resources: Once analysed, the data were used to estimate the water resources. Gap-filling, rainfall-runoff modelling and other methods of estimation are used.

c) Remark: estimation of groundwater resources has also been undertaken and will be taken into account in the water balance.

d) Construction of the water resources – water balance model

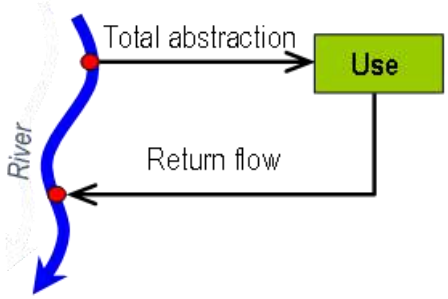


Table 5-13: Comparison of water allocation modelling tools

	WEAP	Spread sheet (Excel)	Mike Hydro	Magre (BRL softw are)	HEC-ResSim	Comment
Flexible tool, user-friendly, possibly used for concentration	3	3	1	2	1	
Basin planning tool (test of scenarios)	3	2	3	3	3	
Appropriate time step	3	3	3	3	3	
Not expensive	3	2	1	3	3	Models noted 3 are free
Well known software (maintenance and improvements)	3	3	3	1	3	

	WEAP	Spread sheet (Excel)	Mike Hydro	Magre (BRL software)	HEC-ResSim	Comment
Appropriate geographical scale and propagation	3	1	3	1	3	No need for propagation in the area under study
Water uses to be considered	3	2	3	3	3	
Linked with other existing initiatives	2	2	3	1	1	WEAP and Mike Hydro are compatible with the Nile-DSS. Mike basin was used in the NWRA and in the JICA study
Ability to answer to the "what if" questions	3	1	3	3	3	
Indicative total	26	19	23	20	23	

WEAP is a user-friendly software tool developed by the Stockholm Environment Institute (SEI) that takes an integrated approach to water resources planning and more details can be found on the WEAP website www.weap21.org, including the details of the following WEAP highlights. It has two primary functions:

- Simulation of natural hydrological processes (e.g., evapotranspiration, runoff and infiltration) to enable assessment of the availability of water within a catchment; and
- Simulation of anthropogenic activities superimposed on the natural system to influence water resources and their allocation (i.e., consumptive and non-consumptive water demands) to enable evaluation of the impact of human water use.

A basic assumption of the WEAP model is that when a rainfall event occurs in a defined hydrological area, part of the water is stored in that area, some of it is lost through evapotranspiration, and part is lost from the catchment as surface runoff of the catchment Q. Simply situate, Precipitation is either transferred to surface run off, evaporates or is stored in the ground or in existing reservoir. That being said, the water balance is simply:

Water inflows = water outflows ± changes in storage

The basic water balance equation in such a situation then becomes:

P – Q – ET + Gin – Gout = Ds

Where:

- P is precipitation,
- Q is surface run off from the catchment,
- ET is evapotranspiration,
- Gin is Groundwater inflow,
- Gout is groundwater out flow,

and

- Ds is change in storage

Over a long period of time for a given catchment, Ds = 0. Therefore, P – Q – ET + Gin - Gout = 0.

Then, assuming that Gin and Gout are either equal or negligible:

P – Q – ET =0

P = Q+ET

5.7.2 Standards and codes used in the study

The Hydrological tools adopted in this study conform to the World Meteorological Organisation's Guide to Hydrological Practices, Volume II. (WMO, 2009).

5.7.3 Model calibration

The adopted Soil Moisture Method has 6 main parameters namely Crop Coefficient (Kc), Soil Water Capacity (Sw), Runoff Resistance Factor (RRF), Root Zone Conductivity (Ks), Deep Water Conductivity (Dw), Preferred Flow Direction (f). Form the sensitivity analysis, the best fit for runoff from the initial model test runs illustrated that the most sensitive to parameters include Sw, RRF, Kc and Dw. Estimation of

model parameters was carried out using an automated tool known as PEST (Parameter Estimation) which is a free software package for Model-Independent Parameter Estimation and Uncertainty Analysis. The tool is an add in WEAP but it is also available for download at http://www.pesthomepage.org. To use the PEST tool, ranges of parameter estimates are provided and the tool run by randomly selecting parameters from the provided ranges. The best fit parameter set consists of the values for these parameters that give the best fit to the observations specified. Figure 5-12 and Figure 5-13 shows the best fit values for the river.

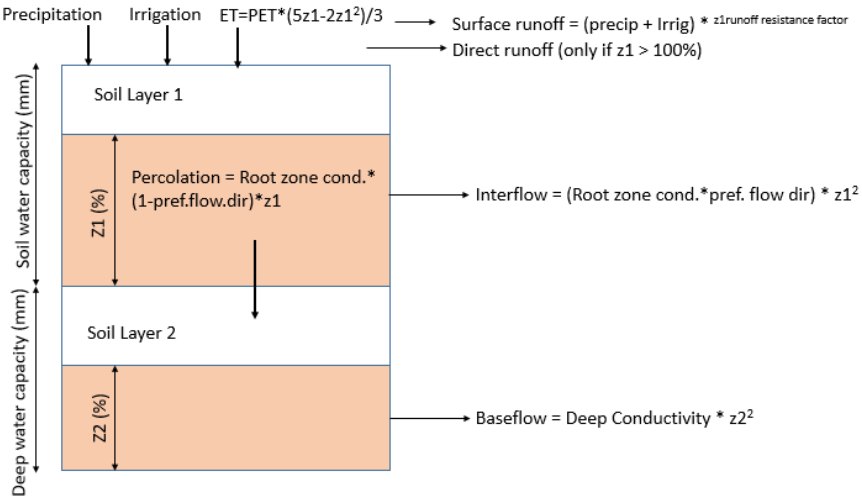


Figure 5-12: Structural framework of the main parameters and input variables

1	Crop coefficient, Kc Runoff Resistance Factor, RRF Soil Water Capacity, Sw Initial Z1 (Z1) Preferred Flow Direction, f Root Zone Conductivity, Ks	In WEAP a parameter must be assigned to each disaggregation class in the catchment (Land cover Land Cover - Soil)	**Kc** **RRF** **Sw** **Z1** **f** **Ks**	Entire Model per class (Land cover/Land Cover - Soil) per class (Land cover/Land Cover - Soil) per class (Land cover/Land Cover - Soil) per class (Land cover/Land Cover - Soil) per class (Land cover/Land Cover - Soil)
2	Initial Z1(Z2) Deep Conductivity, Kd Deep Water Capacity, Dw	In WEAP a unique parameter is assigned in the catchment	**Z2** **Kd** **DW**	Catchment Catchment Catchment

Figure 5-13: Main Parameters of the Soil Moisture Method

5.7.4 Micro-catchment inflows and outflows

Water balance estimation can be thought of as an analysis to assess the current status and trends in water resources availability in an area over a specific period of time and to strengthen water management decision-making by assessing and improving the validity of visions, scenarios and strategies. More specifically, the provision of appropriate and sustainable water infrastructure in the micro-catchments and the subsequent equitable water use and allocation need to be based on a reliable estimate of the water balance within the basin. The annual stream discharge is mainly composed of interflow that contributes a major part of flow during the wet season and is followed by the base-flow that is critical to sustaining the stream flow during the dry season. The micro-catchment inflows and outflows at micro-catchment level are summarized in Table 5-14 and Figure 5-14. From the analysis, it was observed that R. Muyembe is an effluent river with negative base flow values. In the WEAP model, **negative base flow** in the "Land Class Inflows and Outflows" results indicate that groundwater is supplying water to the surface water system, rather than the other way around. This typically happens when the water table is higher than the stream or river, and groundwater naturally flows into the surface water body. Negative surface runoff values in the Land Class Inflows and Outflows report typically indicated that the model is simulating a loss of water from the surface to other hydrological components within the catchment area. This could be due to factors like infiltration into the soil, evaporation, or water being routed to other parts of the model (e.g., groundwater or streamflow).

Table 5-14: WEAP monthly catchment inflows and Outflows in Lower Muyembe microcatchment level

Microcatchment	Variables	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Lower Muyembe	Base Flow	504475.7957	288959.0014	379430.7011	1061556.634	1782442	171647 6	1507841	1703645	1934447	1912950	1630743.332	102394 5	15446911.32
	Decrease in Soil Moisture	1005601.101	278897.7747	0	0	0	991559.2	0	0	0	281896.8	816829.3763	199082 4	5365608.725
	Evapotranspiration	-2028792.927	-1723259.013	-3460298.479	-4032197.044	-4179041	-368453 2	-3635887	-4070404	-4262121	-4355703	-3768456.467	-270503 0	-41905721.06
	Increase in Soil Moisture	0	0	-1893186.504	-1918025.787	-527572	0	-177737	-655170	-173744	0	0	0	-5345435.871
	Interflow	703882.6613	471061.9359	1676867.855	3882361.441	4983107	401294 7	3898425	4679599	5086346	4803129	3819442.193	168118 3	39698351.28
	Precipitation	2249557.87	2214800.432	7555767.248	12407604.71	1375514 2	924484 5	1026422 1	1309317 8	1376281 5	1258581 9	9135589.236	346888 7	109738227.5
	Surface Runoff	10982.54651	8837.829344	159978.1209	1524505.727	2286599	816129.3	1045389	1988749	2307433	1793904	728738.2028	39801.71	12711047.82

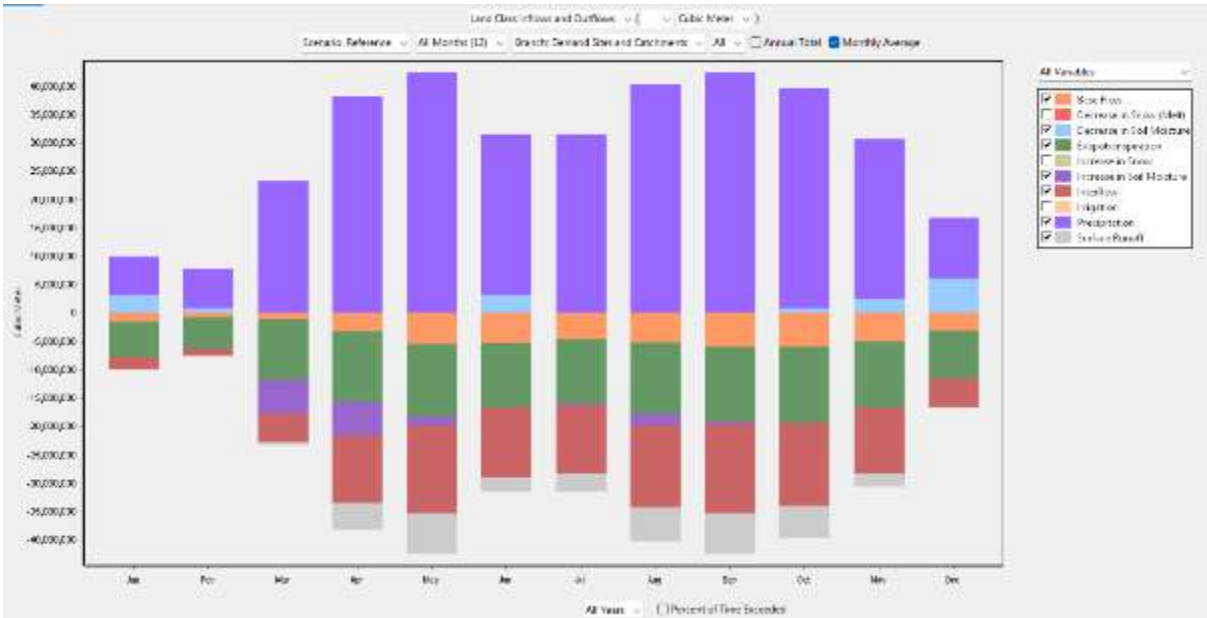


Figure 5-14: WEAP model water balance results for Muyembe

6 CATCHMENT WATER BALANCE

6.1 Water balance modelling

The objective of the analysis was to compare the water demand (current and future) with the water resources available. It indeed provides information to decision makers about questions such as

- What is the current situation of water availability, where are the area where water stress is highest?
- What would be the impact of an increase of water abstraction upstream on downstream water users? Will new abstraction point upstream prevent already existing water demand to be met?
- What would be the impact of a large dam on the water demand-water resources balance?
- Etc.

Such information will be used, together with information from other deliverables and the cost-benefit analysis, to evaluate the different possible measures to be included in the water source protection plan. The choice of a modelling software was done carefully, in order to make sure that the model chosen allow answering the question at stake, and be adapted to the context (type and size of the catchment, data available etc.). However, it is worth keeping in mind that the choice of the model is not the most important step of the modelling approach as most of the models are somehow transposable.

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-

The water resources-water demand balance undertaken took into account the following:

a. Total water abstraction for irrigation water demand, domestic water demand, livestock and industrial uses

b. Return rate (share of the total water abstracted returning to the river). Taking into account return rate is especially needed to take into account water transfers between sub-catchments, when water abstracted in a given sub-catchment is associated to return flow in another sub-catchment.

   i. For rural water supply, given the low amount of total water abstracted and the general absence of wastewater collection network, it's assumed that the return flows are low and around 10%

   ii. For urban water supply, where the overall water abstraction per capita is higher, a larger share of the water is assumed to return to the river. This share is estimated to be equivalent to 80% of the total abstraction.

c. Part of the water demand is supplied by surface water resources, but part of it is also supplied using groundwater. This specificity was taken into account. In the water resources-water demand balance

   i. Irrigation water demand: the share of irrigation abstraction relying on groundwater was considered negligible. Most of the irrigated areas uses water from rivers or wetland and the cost of pumping groundwater is often prohibitive compared to the water volume needed.

   ii. Domestic water demand: the share of domestic water abstraction was considered on both surface and ground water.

   iii. Livestock watering: there is little data regarding the use of surface or groundwater for livestock watering. Surface water is for sure the main source, through direct abstraction from the rivers or the use of valley tanks or valley dams. However, the use of groundwater is also possible. In absence of more precisely quantified data or information, the assumption used in the analysis is that 100% of demand for livestock watering is from surface water.

The elements that comprise the water demand-supply system and their spatial relationship are defined for the catchment under consideration. The system itself was represented in terms of:

- its various water sources (e.g., surface water, groundwater and water reuse elements);
- withdrawals, transmission, reservoirs, wastewater treatment facilities, and

Water demands (i.e., user-defined sectors, but typically comprising industry, mines, irrigation and domestic supply, etc.).

6.2 Water balance projections

Water balance projections (Figure 6-1 and Table 6-1) up to 2050 indicate satisfaction of the catchment water resources with withdraws of up to 23.68% of available water, below SDG

6.4.2[1] and FAO's physical water scarcity[2]level at 75%. Per capita water availability (1743.08 m^3/person/year) within the microcatchment was above the Falkenmark threshold water stress[3] implying that the micro-catchment is not either physically or economically water scarce.

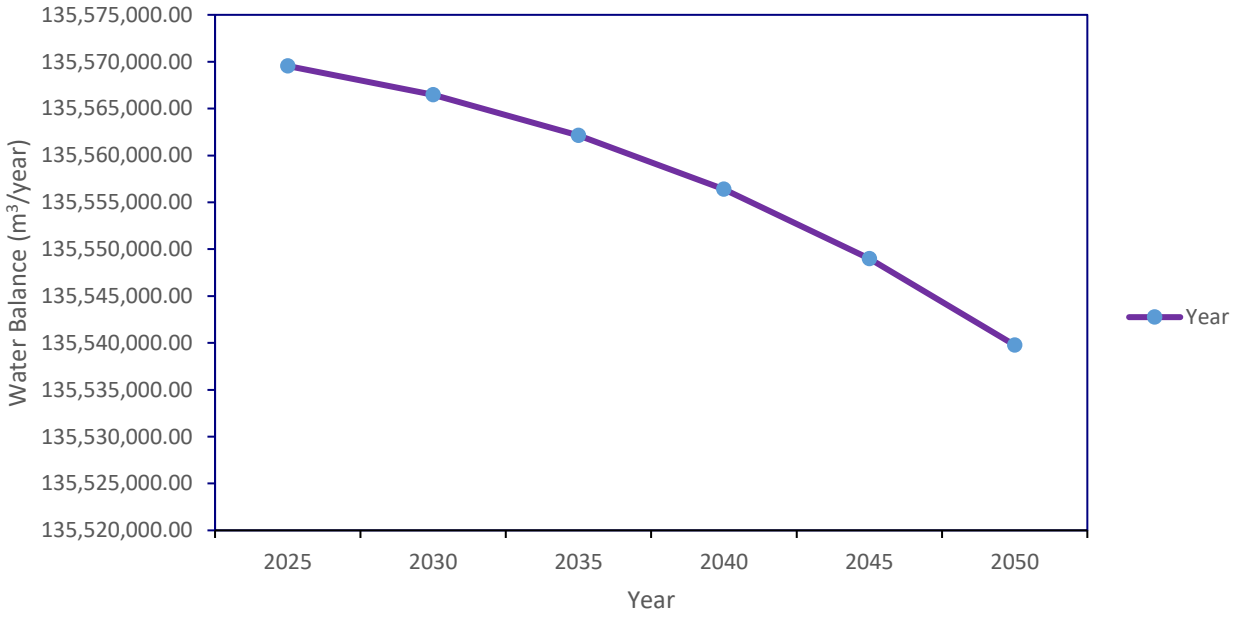


Figure 6-1: Projected water balance in Lower muyembe microcatchment

[1] SDG 6.4.2 measures water stress as the percentage of freshwater withdrawals against total renewable freshwater resources. The water stress thresholds are: no stress <25%, low 25%-50%, medium 50%-75%, high 75%-100%, and critical >100%

[2] FAO definition of physical water scarcity which is encountered when more than 75% of the river flow is withdrawn for agriculture, industry and domestic uses.

[3] The Falkenmark Water Stress Index measures water scarcity as the amount of renewable freshwater that is available for each person each year. A catchment is said to be experiencing water stress when water availability is below 1,700 m^3 per person per year; below 1,000 m^3 is considered water scarcity; and below 500 m^3 is absolute or severe water scarcity.

Table 6-1: Projected (2050) Water Balance for Lower Muyembe microcatchment

Year	Population	Available Water (m^3/year)	Evapotranspiration (m^3/year)	Water Demand (m^3/year)						Water Balance (m^3/year)
				Domestic	Livestock	Industrial	Irrigation	Environmental Flow	Total	
2025	41941.97	177,594,538	41,905,721	34,193	8,134	423	76,449.18	77.30	119,277	135,569,540
2030	47453.47	177,594,538	41,905,721	39,639	9,429	491	72,702.41	77.30	122,339	135,566,478
2035	53689.14	177,594,538	41,905,721	45,953	10,931	569	69,139.27	77.30	126,669	135,562,148
2040	60744.55	177,594,538	41,905,721	53,272	12,672	659	65,750.76	77.30	132,431	135,556,385
2045	68727.00	177,594,538	41,905,721	61,757	14,690	764	62,528.32	77.30	139,817	135,549,000
2050	77758.43	177,594,538	41,905,721	71,593	17,030	886	59,463.81	77.30	149,050	135,539,766

Discussion of Results – Limitation of the Water Balance

The purpose of a water balance is to conduct a simple evaluation of the catchment inflows and outflows. But it is important to understand the limitations of simple water balances such as the one used here, especially in basins where limited data is available.

- The watershed boundaries were assumed to be identical to the surface water hydrology, but not the groundwater hydrogeology. Groundwater within the basin may be influenced by a regional system that extends beyond the watershed boundaries.
- Water balances are not adequate to evaluate the potential influence of an increase in groundwater use for catchments with complex hydrology or large groundwater use. This is because groundwater use is dependent upon aquifer hydraulics, spatial and temporal characteristics and the capture of natural discharge and water balances cannot be used to accurately evaluate any of these factor.
- Water balances are only valid to describe existing conditions where sufficient empirical data is available.

7 ALTERNATIVE CATCHMENT SCENARIOS

7.1 Developing Planning Objectives

The planning team developed objectives that are consistent with the catchment set goals, but also to provide a more operational framework for the evaluation of alternatives. During the situational analysis phase, the planning team identified some pertinent issues that required further investigations. These among others included; water quality, water shortages, flood inundated areas and others that were elicited and prioritized by the stakeholders, the water resources as well as strategic social and environmental aspects have been insightfully elaborated and discussed. This led to an agreement to a common direction and understanding for a sustainable integrated future development of the sub-catchment for the socio-economic benefit of its people and its environment considering the above mentioned situation and background.

Table 7-1: Prioritisation of Micro-catchment issues

Sub-county	Issues	Ranked by SCMC
Muyembe and Nabongo	▪ Soil erosion ▪ Poor farming methods (over use of artificial fertilisers) ▪ Intense farming practices on landscapes ▪ Poor waste management ▪ Poor water quality ▪ Unreliable safe water for domestic use ▪ Infrastructure deterioration ▪ Siltation of the drainage system ▪ Flooding ▪ Land fragmentation	▪ Flooding ▪ Poor waste management ▪ Poor water quality ▪ Unreliable safe water for domestic use ▪ Infrastructure deterioration ▪ Siltation of the drainage system ▪ Soil erosion ▪ Land fragmentation ▪ Poor farming methods (over use of artificial fertilisers) ▪ Intense farming practices on landscapes
Masiira	▪ Intense farming practices on landscapes ▪ Deforestation ▪ Poor water quality ▪ Poor waste management ▪ Landslides ▪ Land fragmentation ▪ Soil erosion ▪ Poor farming methods (over use of artificial fertilisers) ▪ Use of fertilisers and pesticides	▪ Intense farming practices ▪ Deforestation ▪ Land and mudslides ▪ Land fragmentation ▪ Soil erosion ▪ Over use of natural fertilisers and pesticides ▪ Poor water quality (Impairment from laundry) ▪ Poor waste management ▪ Unsustainable Water diversions on the river Land fragmentation
Kaserem and Kapsinda	▪ Intense farming practices on landscapes ▪ Stone Quarrying ▪ Pesticide use ▪ Land slides ▪ Mudslides ▪ Soil erosion ▪ Poor farming methods	▪ Intense farming practices on landscapes ▪ Stone Quarrying ▪ Pesticide use ▪ Land slides ▪ Mudslides ▪ Soil erosion ▪ Poor farming methods

Sub-county	Issues	Ranked by SCMC
	▪ Use of pesticides ▪ Deforestation ▪ Soil erosion	▪ Use of pesticides ▪ Deforestation

7.2 Vision and Strategic Objectives

The Sub Catchment Management Committee Workshop held in Kapchorwa between 21st Nov. 2024, and 26th March 2025 in Gamogo and Buginyaya sub-counties agreed on a vision and mission where they would like to see their Micro-catchment in 2040 (in line with the Uganda Vision, Kyoga water management zone and Awoja Catchment Management Plan's Vision). The process took into account the issues, strategic implications and catchment driving factors. The proposed visions and Missions were as shown in Table 7-2:

Table 7-2: Proposed Visions and Missions

No.	Vision	Mission
1	To create a sustainable management forum with bankable projects	To establish an operational Sub-catchment management committee for coordination and implementation of CRAP
2	To establish well organized resource user groups	To allow for effective and efficient exploitation of natural resources (water, land, soils, and forests)
3	To increase fisheries productivity	To improve water quality and quantity
4	To reduce catchment related disasters	To create cost-effective structural and non-structural measures
5	To adopt equitable use of water resources (Water for energy, production and people)	To optimize water use through planning and allocation (demand prioritization and supply preference)
6	To improve the general livelihood of the dependents	To enhance capacities of the dependents
7	To enhance resilience against climate change	To improve knowledge base of the communities in adoption measures
Harmonized	**"To create sustainable, manageable and bankable strategies geared towards improving productivity, equitable and sustainable use of natural resources to foster enhanced livelihoods and climate change resilience by 2035"**	**Through holistic engagement of stakeholders in managing natural resources within the catchment**

In order not to lose sight of what the planning process desired to accomplish, the KWMZ planning team and the MCMC went through a process together to agree on the strategic objectives and

outcomes that Lower Muyembe Micro-catchment plan should aim to achieve as listed in the Table 7-3 below.

Table 7-3: List of formulated strategic objectives

No.	Strategic Objective
1	Conservation of water , soil and ecosystems
2	Sustainable and equitable use of available resources
3	Offer alternative livelihood through bankable projects
4	Enhance resilience against climate change
5	Monitoring of the hydro-meteorological information
6	Widening the knowledge base of the communities/ institutions in sustainable natural resources exploitation
7	Improving the water quality and quantity to proliferate fish productivity in L. Opeta and L. Bisina
8	Enhancing stakeholders' participation in the catchment management activities
9	Identify and prioritize potential investment options
Harmonized	A. To conserve and develop sustainable alternatives to natural resource use within the catchment; B. To ensure improved water quality and quantity to proliferate fish productivity downstream; C. To improve community livelihoods and socio-economic development within the sub-catchment; D. To enhance resilience of communities to climate change through community development and stakeholder engagement.

7.3 Options and Scenarios Analysis

To achieve the vision and strategic objectives, there was need to undertake measures which address the main issues and reverse those trends that undermine sustainable development in Lower Muyembe Micro- catchment. These measures are referred to as options.

A range of potential options to consider in the MCMP were gathered from Stakeholder consultations, focus group discussions, community engagements, workshops, situation analysis, and literature review to support the identification of intervention opportunities that contribute to the achievement of the vision, Mission and the strategic objectives. The options for the Micro-catchment management interventions that respond to the identified issues are elaborated. Through a scenario analysis the ideal combination of options was determined. Some actions are already being undertaken by the development partners like WWF, SAEMs among others, local government and other institutions to address issues like livelihood, soil erosion, and deforestation among others.

Since many of the options can be found in the portfolio of planned or completed projects lying with the sector departments (e.g. water for production in MWE), layouts, design criteria, and cost and benefits should exist. However, it should be noted that there are two broad types of options; investment or physical options and management actions. Actions might be related to construction of infrastructures (domestic water supply network, sanitation system, storages for one or more purposes, fish ponds, etc.) or they are referred to implementation of actions on water governance, information systems, capacity building, etc.

Based on the situation analysis of the catchment linked to the issues and particularly in regard to the different landscape zones, options were developed and classified under four thematic areas. Figure 7-1 outlines the different thematic areas (1, 2, 3, and 4) linked to their respective options and sub-options. These options are specified in this section, after which they are analyzed in the scenarios section and then lead to interventions.

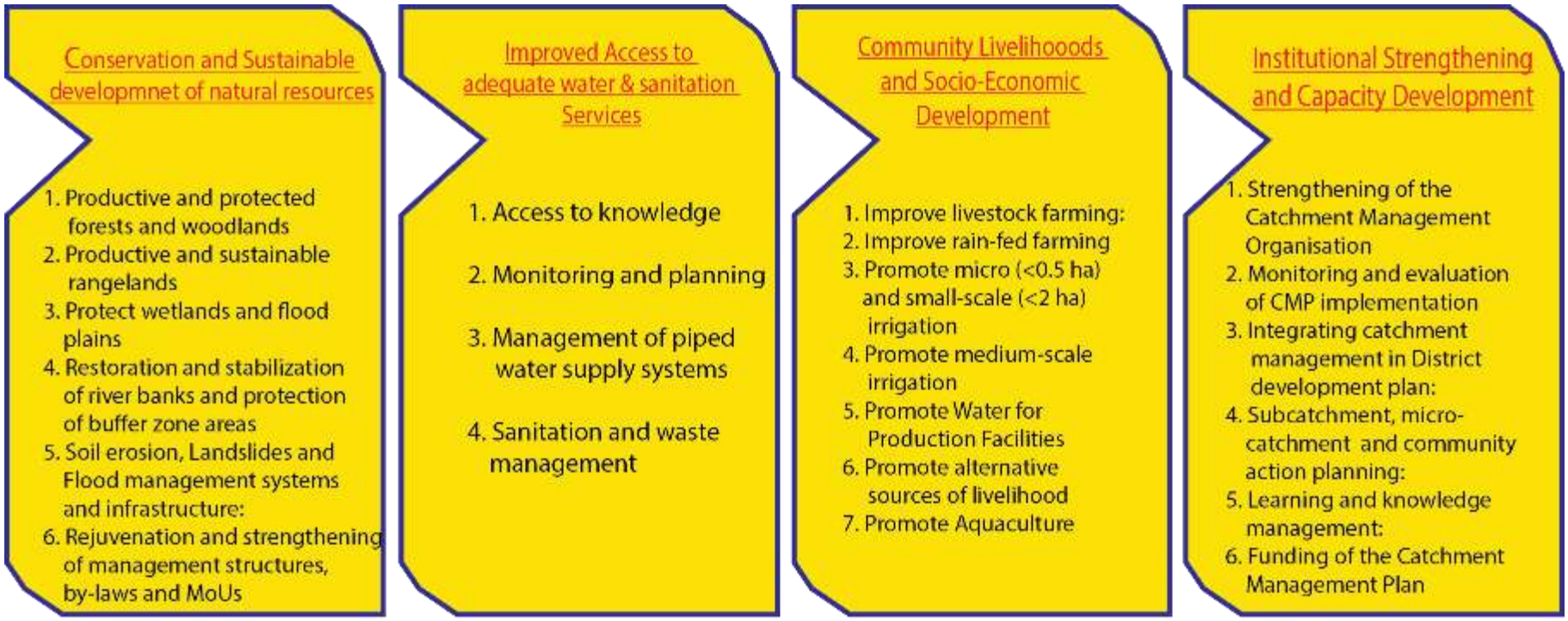


Figure 7-1: Management actions and potential investment options

Since the options are very broad and general, Sub-options (implementation actions) were identified which are specific, suitable and tailored to the different areas in Lower Muyembe Micro-catchment and contribute to achieve the objectives.

These thematic areas relate strongly to the aspects raised in the four strategic objectives and thus the vision and mission. The last thematic area, the “institutional strengthening and capacity development” is overarching and cross-cutting referring to all thematic areas and their options. Some interventions are proposed to be piloted as no-regret measures. No Regrets measures are based on concepts and measures that can begin to be enacted without being certain about all dimensions of future climate change. Measures are taken and strategies are thus adopted in a precautionary sense with the aim of responding to possible negative impacts before they intensify. Such measures are advisable for future generations, but also relevant to enhancing the living conditions of people in the present. Typically, they cross the boundary between adaptation and mitigation. With No Regrets strategies, the benefits of adaptation and mitigation measures therefore continue even if the effects of climate change are not as horrific as currently anticipated. The following interventions (Table 7-4) are suggested to be piloted as no-regret IWRM measures:

Table 7-4: List of No-Regret measures

No	**1. On agroforestry systems**
1.1	Create awareness in conservation of protected areas (Mount Elgon National Park)
1.2	Build the capacity on conservation methods
1.3	Build the capacity on conservation methods
1.4	Establish community managed tree nurseries, establish distribution, creation of wood lots, live fencing and promote planting
1.5	Promote, provide training of trainers and enable access to information on alternative sources of energy and promote the adoption of energy saving practices/tools
1.6	Introduce/ promote practices that allow regeneration of natural vegetation
	2. On restoration, management and enhancement of resilience of vulnerable ecosystems
2.1	Support the participatory development of river banks, buffer zones and wetland management plans and ensure the restoration and demarcation of degraded wetlands
2.2	Facilitate the adoption and enforcement of controlled grazing in riverine areas
	3. On increased resilience to climate change impacts such as drought and floods
3.1	Alternative livelihood activities for vulnerable communities or communities living in hot spot areas such as wetlands

3.2	Promote 3R interventions (Recharge, Retention and Reuse) in flood prone areas of selected sites.
	4. Promotion of sustainable natural resource management concepts (Ecologically sound, Economically Viable, and Socially just, Humane, and Adaptable)
4.1	Promote use of local resources in a way that minimizes losses of nutrients biomass energy and avoids pollution
4.2	Emphasize use of renewable resources
4.3	Increase farmer's production to produce enough for self-sufficiency and/or income. And again sufficient returns to warrant the labor and costs involved
4.4	Promote distribution of resources and power in such a way that the basic needs of all members of society are met and their rights to land-use, adequate capital, technical assistance and market opportunities
4.5	Rural communities are capable of adjusting to the constantly changing conditions for farming
	5. Water resources management
5.1	Control flooding structures at the hotspot areas identified
5.2	Construct reed beds at to minimize acid mine drainage emissions into the river
5.3	Control runoff over stockpiling to reduce runoff and erosion of metal sediments into the river
5.4	Regulate flow in the River and control siltation and transport of sediments and boulders
5.5	Install gauging stations for both runoff and water quality monitoring

7.3.1 Screening of the Options

Prioritization of options was instrumental derived using the Options Matrix Tool (OMT) as Multiple-Criteria Decision-Making (MCDM). The options matrix tool (OMT) is a spreadsheet-based decision making tool designed to help planners apply a set of decision criteria to a variety of alternatives or strategic options.

The approach provides a mechanism for the screening of options by the selection of weights against social, environmental, and economic screening criteria. In this regard, a scoring process was developed and the scores were allocated to different options. However, the scores remain subjective, but in presence of good information about the options together with knowledgeable people applying the criteria, results become less subjective. This leads to an informed opinion on options, based on best understanding of the water resource situation and the social, environment

and economic circumstances prevailing. Options were evaluated against a defined set of criteria, based on available information, which reflect the vision and objectives of Lower Muyembe Micro-catchment.

The development of an options matrix involved several steps, as follows:

i. Identification of options (alternatives) to be considered;
ii. Selection of criteria that are most important for evaluating options;
iii. Assigning weights (magnitude) to each of the criteria;
iv. Selection of minimum acceptable scores for each criterion; and
v. Rating or evaluation of each option on the criteria using a scale

Table 7-5: Explicit OMT for prioritizing the options

		Criteria											
Description		Watershed Protection and Enhancement	Improvement of Water Quality	Wetland Conservation	Well balanced use of water resources	Mitigation/ Adaptation to natural disasters and climate change	Income increase per capital	Improved food production per capital	Feasible Cost	Ease of implementation (physical feasibility)	Capacity to implement	Consequences of failure to implement	Sustainability	Total Score
Weighting		**Low (1) Medium (3) High (5)**	**Low (1) Medium (3) High (5)**	**Low (1) Medium (3) High (5)**	**Low (1) Medium (3) High (5)**	**Low (1) Medium (3) High (5)**	**Low (1) Medium (3) High (5)**	**Low (1) Medium (3) High (5)**	**Very difficult (-3) Difficult (-2) Feasible/ possible (2) Very feasible (3)**	**Prohibitive (-5) Very expensive (-3) Expensive (-1) Reasonably affordable (3) Very affordable (5)**	**None/inadequate (-3) Weak (-2) Capacity to be built/recruited (-1) Limited capacity (1) Good - available (3)**	**None. Issue(s) will resolve naturally over time (-3) Issue(s) increase but remain at same relative scale (0) Escalation of issue(s) (3)**	**Definite long-term sustainability (5) Sustainable (3) Uncertain-it depends (0) Short-term only (-3) Most unlikely (-5)**	
Options	Conservation and Sustainable development of natural sources	♥	♥	♥	♥	♥	♥	♥	♥	♥		♥	♥	
	Improved access to adequate Water and sanitation services	♥	♥	♥	♥	♥	♥	♥	♥	♥		♥	♥	
	Community Livelihoods and Socio-economic development		♥	♥	♥		♥	♥	♥	♥		♥	♥	
	Institutional Strengthening and Capacity Development	♥	♥	♥	♥			♥	♥		♥	♥		

7.4 Scenario Analyses

A set of assumptions about the options in place, external factors that influence their performance, projections or forecasts of the future, and government policy affecting either selection or performance. Thus, a scenario analysis was undertaken to assess the “behavior” and impact of sets of options under certain expected circumstances or trends. Such analysis aims to select or prioritize those sets of options that counter certain negative trends or accelerate positive trends. This section introduces the scenarios, shows which trends take place when no interventions are carried out and then describes the impact of the options at catchment level when implemented.

By considering the various options and regrouping them, different scenarios were developed along the four thematic areas of options leading to the achievement of the strategic objectives. They are useful to provide a perspective on potential bankable prospects and their associated impacts. From the analysis, four scenarios ranked highly were formulated but since option 4 for institutional strengthening and capacity development was crossing cutting, we focused on the 3 scenarios as highlighted in Table 7-6below.

Table 7-6: Highly ranked Options to Scenarios

Scenario	Description
1	Soil and water conservation and Protection
2	Improved access to water resources through sustainable infrastructure development
3	Enhanced productivity through sustainable intensification

7.5 Multi-criteria evaluation

The comparison and assessment of scenarios was done in the context of the multi-criteria evaluation framework. Multi-criteria analysis (MCA) establishes preferences between scenarios by reference to an explicit set of strategic objectives. This sets the ground for discussion of what is better or almost as good, or not good at all basing on the objectives and indicators set for the plan. Different micro-catchments have different needs and thus different prioritizes. The three scenarios were then compared using the ranked options and the objective functions of the scenarios. It points to the fact that these are the three different ways of meeting all the planning objectives while trying to maximize the objective function in each case. Having compared the three scenarios (Table 7-7), SC1 emerged the highly ranked scenario.

Table 7-7: Comparison of the three scenarios

No	Option/Sub-option	Screened Totals for Sub-options	Scenario 1	Scenario 2	Scenario 3
1.1.1	Improve tree cover in degraded hotspot areas	21	21	21	
1.1.2	Regulate charcoal production and firewood use	33	33		
1.1.3	Promote use of alternative sources of energy	29	29		
1.1.4	Provide routine training to SCMC, forest management, land care and agricultural managers	14	14		
1.2.1	Promote collaborative rangeland management with traditional rangeland management institutions and other stakeholders	10	10	10	
1.2.2	Protect and rehabilitate rangelands	14	14		
1.2.3	Design and pilot of individual farms according to sustainable land and environmental management principles. Layout to include contouring, drain and waterway layout and improvements, road design, runoff management, woodlot and agroforestry planning	25	25	25	
1.3.1	Sensitize and create awareness on the value of wetlands	23	23		
1.3.2	Development and implementation of community based wetland restoration and management costed plans	19	19	19	
1.3.3	Restoration and Demarcation of degraded wetlands	27	27	27	
1.3.4	Development of community based action plans and GIS maps at various levels	16	16		
1.3.5	Formulation of the wetland management structures, by-laws and MoUs	24	24	24	

No	Option/Sub-option	Screened Totals for Sub-options	Scenario 1	Scenario 2	Scenario 3
1.4.1	Sensitize and create awareness on the value of rivers and buffer zones	28	28		
1.4.2	Rapid assessments on the level of river bank degradation and encroachment on buffer zones	22	22	22	
1.4.3	Development and implementation of river bank and buffer zone restoration plans	24	24	24	
1.4.4	Formulation of river banks and buffer zone management structures, by-laws and MoUs	19	19		
1.5.1	Flood mapping and early warning systems	14	14		
1.5.2	Development and Implementation of designs and plans for flood control and Water harvesting structures, and biophysical structures	20	20	20	
1.5.3	Formulation of flood control and Water harvesting structures, and biophysical structures management committee, by-laws and MoUs	13	13		
1.5.4	Demarcate areas considered unsafe for habitation or other use and warn inhabitants - Landslides	22	22		
1.5.5	Restore areas most susceptible to soil erosion and biggest suppliers of sediment	19	19	19	
1.5.6	Development and Implementation of a fire risk, fire control and fire protection plan with controlled burning required for grazing and biodiversity management and implement it	6	6		
1.6.1	Support enforcement of regulations	15	15	15	
1.6.2	Regulate stone quarrying and sand mining	10	10		
2.1.1	Promote capacity building	19	19	25	

No	Option/Sub-option	Screened Totals for Sub-options	Scenario 1	Scenario 2	Scenario 3
2.1.2	Support extension services	24	24	24	
2.1.3	Improve knowledge management	25	25	25	
2.2.1	Reinstate climate monitoring	6	6		
2.2.2	Establish groundwater monitoring network plan	-5	-5	-5	
2.2.3	Strengthen surface water monitoring	8	8	8	
2.2.4	Establish water quality monitoring	27	27	27	
2.2.5	Establish flood monitoring	18	18	18	
2.2.6	Enforce the water abstraction permit system	12	12	12	
2.3.1	Extend and rehabilitate water supply systems	14	14	14	
2.3.2	Construct new water supply systems	16		16	
2.3.3	Rehabilitate and close non-functional water points	16		16	
2.3.4	Improve operation and maintenance	13		13	
2.5.1	Development of Water Allocation plans	25	25	25	
2.5.2	Rainwater harvesting for supplemental water supply	36	36	36	36
2.5.3	Bulk Water Transfer Schemes from L. George	24	0	24	36
2.5.4	Development of Multipurpose Water Resources Infrastructure	32	32	32	32
2.5.5	Development of Water for Production Facilities: Valley tanks and Earth dams	34	34	34	34
2.3.5	Promote water harvesting for domestic use	31	31	31	31
2.4.1	Upscale sanitation programmes	31		31	
2.4.2	Promote waste management	25	25	25	

No	Option/Sub-option	Screened Totals for Sub-options	Scenario 1	Scenario 2	Scenario 3
3.1.1	Develop and implement a plan to improve access to water for livestock (and irrigation)	12		12	
3.1.2	Improve access to pasture and rangeland management	14	14	14	
3.1.3	Improve knowledge management	15	15	15	
3.1.4	Livestock improvement programme	10			10
3.2.1	Promote sustainable and productive rain-fed farming	26	26		26
	Improved farming practices	20	20		20
3.3.1	Promote micro- and small-scale irrigation	18	18		18
3.4.1	Promote medium-scale irrigation	18	18		18
3.5.1	Condition assessment and Rehabilitation of water for production facilities (Valley dams and Tanks)	14	14	14	
3.5.2	Needs identification for location and type of dams and associated abstraction facilities	12	12	12	
3.6.1	Promote alternative economic activities – Bee keeping, Horticulture	22	22		
3.7.1	Develop a manual on aquaculture techniques building on available materials	12			12
3.7.2	Assist farmers with rehabilitation of viable aquaculture ponds and in the construction of new ponds	22	22		
3.7.3	Train and assist farmers on the appropriate fishing techniques and equipment as well as the protection of breeding grounds	24			24
3.8.1	A systematic analysis of each commodity production and handling system	16			16

No	Option/Sub-option	Screened Totals for Sub-options	Scenario 1	Scenario 2	Scenario 3
3.8.2	Harvesting at the proper maturity stage and at peak quality	22			22
3.8.3	Grains should be dried in such a manner that damage to the grain is minimized and moisture levels are lower than those required to support mold growth during storage (usually below 13-15%)	24			24
3.8.4	Construction of Stores in such a way as to provide: Dry, well-vented conditions allowing further drying in case of limited opportunities for complete drying prior to storage; -Protection from rain and drainage of ground water; and -Protection from entry of rodents and birds and minimum temperature fluctuations	14			14
3.8.5	Provision of the proper tools and equipment for harvesting and training workers in their correct use should be a priority prevention of food loss activity	14			14
3.8.6	Care must be taken to minimise physical damage that results from impact bruises due to stacking and overfilling of bags, abrasion or vibration bruises due to root movement against each other	15			15
3.8.7	Improve the existing store types	15			15
4.1.1	Implementation of CMO governance system	11	11	11	11
4.1.2	Support and strengthen the CMC	19	19	19	19
4.1.3	Establish the CMS	12	12	12	12
4.1.4	Support and strengthen the CSF	9	9	9	9

No	Option/Sub-option	Screened Totals for Sub-options	Scenario 1	Scenario 2	Scenario 3
4.1.5	Establish and support the CTC	11	11	11	11
4.2.1	CRAP review	12	12	12	12
4.2.2	Policy development	14	14	14	14
4.3.1	Prepare districts for CMP implementation	14	14	14	14
4.3.2	Cross-sectoral district operations	8	8	8	8
4.3.3	Guide development partners	9	9	9	9
4.4.1	Sub-catchment management	17	17	17	17
4.4.2	Micro-catchment management	19	19	19	19
4.5.1	Awareness raising on CBWRM and CRAP	16	16	16	16
4.5.2	Capacity building	12	12	12	12
4.5.3	General stakeholder learning	14	14	14	14
4.5.4	Knowledge management	17	17	17	17
4.6.1	Proposal and partnership development	14	14	14	14
4.6.2	Innovation fund (basket fund)	7	7	7	7
	Total		**1214**	**959**	**652**
	Rank		**1**	**2**	**3**

8 CONSENSUS CATCHMENT PLANS

8.1 List of identified, confirmed and quantified priority catchment management investments

Following careful evaluation of the potential options, a preliminary or conceptual design of each option to determine its main specification and characteristics was also prepared. As adopted from the guidelines, small scale and repetitive infrastructure would use standard layouts and designs adapted to each circumstance. The purpose is to enable a preliminary estimate of its costs including operation, maintenance and construction cost. The design specifications include its operating characteristics i.e (flow rate, volume, time pattern, energy use) and outputs (area or number of people served, production, etc.).

The operating characteristics and outputs were then used to estimate the economic benefits of implementing the potential options. The modality of operation and maintenance are specified including who will have this responsibility and what measures and actions need to be undertaken to ensure these critical responsibilities are fulfilled (legal requirements, training, funding, etc.)

The Catchment Implementation Plan is composed by a series of proposed investment and management actions. The definition of investment and management actions prioritization is based on activities related to stakeholders' consultation, identification of issues and opportunities, review of institutional arrangements, policies, and financing mechanism, etc. that are illustrated in the previous paragraphs. This activity leads to identify recommendations for preparing the ground for implementation of the CRAP and timing.

In the Catchment Implementation Plan development of cost and schedule of each action was done by the preliminary cost estimation of each action and the scheduling of the cash flows for each action item. The overall cost for each action is provided both in US dollars ($) and shillings (UGX). It has been considered that 1 US $ is about 3,650 UGX. Estimated investment costs were based on a rate of 1US$ per cubic meter of water volume stored.

Identified catchment management and investment actions include;

Table 8-1: Identified issues per parish/village in the Micro catchment

Sn	Identified Issues	Affected Parishes/Villages	Interventions
1.	Land and mudslides	Mbigi, Kitaka, Nafuta, Jambula, Namutokolo	○ Planting trees and avoid deforestation. ○ Embrace government programs on relocations of people in hotspots. ○ Practice agro-forestry ○ Provision and supply of tree seedlings by the government through the ministry of water and environment. ○ Consultations and community engagements on the right seedlings to be supplied and when.

2.	Infrastrucural Breakdowns	Samazi and Muvule	○ Government and District should priotise construction of all weather bridges in these identified areas. ○ Involve community in maintenance of the bridges.
3.	Poor Water quality	All villages of Samazi and Mbigi parishes	○ Use of water guards on community bore holes and protected springs. ○ Government through the Ministry of water to extend piped water system in these areas. ○ Community sensitization programs and WASH activities.
4.	Poor farming Methods	All villages of Samazi and Mbigi parishes	Community sensitization programmes on the use the proper and scientific farming methods.
5.	Land Fragmentations	All parishes/villages in the Micro-catchment	Community sensitisations on the effects of land fragmentation.
6.	Use of fertilisers	All parishes/villages in the Micro-catchment	Advocating for use of manure through regular senistisations.
7.	Intense farming on slopes	All parishes/villages	Applying soil erosion control methods on slopes like terracing, contour ploughing
8.	Soil erosion	All villages of Bufukhula and Samazi parishes	○ Practice agro-forestry ○ Provision and supply of tree seedlings by the government through the ministry of water and environment. ○ Consultations and community engagements on the right seedlings to be supplied and when. ○ Community sensitisations through extension officers on soil erosion control methods.
9.	Flooding	All villages of Muvule and Bunagaka parishes	○ Community sensitization on the effects of cultivating in wetlands. ○ Desilting of rivers
10.	Poor waste management	All villages of Samazi parish	○ Community sensitization on localized waste handling techniques.

8.2 Investment Plan

This section presents a summary of investment plan (Table 8-2) which insightfully describes the scale of Micro-catchment issues, interventions, allocation of costs, time frame of implementation, thematic area, ranking in priority of implementation, and stage of implementation. A detailed investment plan is attached in Annex C. The Bulambuli DDP (2025-2030) outlines clearly the budgetary allocation as regards restoration of the ecosystem for environment and climate change mitigation.

Table 8-2: Summary Investment Plan in different micro-catchments

S/N	Micro-Catchment Name	Sub-Basins within the Micro-Catchments	Physical /Political boundaries within micro-catchment	Investment Costs (USD)
1	**Lower Muyembe**	Muyembe Sub-catchment	Downstream part of Muyembe sub-catchment, drains R. Muyembe, R. Gibuzali, R. Sirimityo, & R. Nabongo.	2,450,205.28
			TOTAL (USD)	**2,450,205.18**

8.3 Pre-Feasibility studies for identified priority investments

The pre-feasibility assessments are designed to guide decision makers as to whether the project is sound on technical, economic, social and environmental grounds. Further, the assessment considers the existing policy, legal and regulatory environment in which the project would be grounded, and gives a high-level overview of the institutions and other stakeholders – with a view to setting out an initial assessment of project implementation (including financing options). These are laid out in the following approach.

8.3.1 Project Data

Project Name	Catchment Bankable Projects
Location	Lower Muyembe Micro-catchment
Number of Beneficiaries	123,500 people (2035)
Estimated Cost	USD 43,225,000
Time frame	Short Term (1-3 years, Medium Term (3-5 years), Long Term (5-10 years)
Source of funds	▪ Kapchorwa and Bulambuli District Local Government ▪ Ministry of Water and Environment ▪ Ministry of Tourism, Wild life and Antiquities ▪ Ministry of works and Transport ▪ The nine sub-counties within the micro-catchment ▪ The Office of the Prime minister. (OPM)
Community contribution	Land, Unskilled labour, materials, maintenance, monitoring and Evaluation

Development partners	AfDB, World Bank, GoU, GEF, UK Department for International Development (DFID), and private sector

8.3.2 Project Description

Sustainable Land and Environmental Management

From the assessment, a number of interventions are proposed as listed below. This was based on a number of parameters envisaged in the forecasted peak flows, Micro-catchment harvestable yield, soil loss rate, and sediment yield and also ear marked in Bulambuli and Kapchorwa proposed DDP (2025-2030).

Biophysical Interventions

Contour bunds

Stone lines along the contour lines are the simplest form of contour water harvesting system. Construction includes a shallow foundation trench of 15 cm made along the natural contour with larger stones on the downslope side of the trench and smaller stones are used to build the rest of the bund.

Contour bunds are small structures that control erosion, improve infiltration and improve crop yields. The bunds are usually built on hillsides along contours (see Figure 8-1). Contour bunds reduce the speed of run-off, which allows the water to infiltrate, thus improving the soil moisture. Contour bunds come in various designs: stone bunds, soil bunds, tied ridges and stone face bunds.

Figure 8-1: Contour stone bunds

Geographical suitability: Because of the high runoff velocities and therefore increased probability of soil erosion in areas with steep slopes, contour bunds are suitable for use in both the high altitude AEZ and southern and western tall grassland AEZ. However, bunds can also be applied on low slopes, such as in the pastoral arid to semi-arid AEZ, although provision must be made to avoid livestock damaging the structures. Contour bunds are usually implemented on slopes below 15 percent and above 3 percent, preferably on well-drained soils.

Technical & Environmental factors: By intercepting and holding runoff the bund increases water infiltration in the soil, improving soil moisture and, to a limited extent, replenishing shallow ground water. Soil bunds are very effective in diminishing erosion in the farm and in trapping suspended sediments. The fertile sediments accumulate behind the bund, which after some seasons creates a highly fertile bench.

Socio-Economic factors: Contour bunds are valued for their importance in trapping water in the soil profile, which increases levels of rain-fed production. Furthermore, contour bunds are very valuable for catchment restoration activities, for which they provide considerable environmental services by reducing the risk of soil erosion and increased water infiltration. Farmers have the capacity to manage and maintain contour bunds themselves, but would benefit from training to improve their skills. Constructing and maintaining contour bunds is labour intensive, and because women constitute the biggest labour in agriculture, this technology is likely to substantially increase the workload of women.

Productivity and profitability: The augmented soil moisture content and accumulated sediments immediately above the soil bunds lead to higher production in comparison to non-bunded fields. Bunds are commonly strengthened with edible grasses or bushes, such as pigeon pea, which provide a way to diversify farm production.

Bench terraces

Alternating series of ‘shelves’ and ‘risers’ characterize bench terraces (Figure 8-2). They are usually developed on relatively steep slopes (15-55 percent) with deep soils that allow this type of landscaping. The alternating flat surfaces are capable of stopping runoff and increasing water stored in the soil profile. In bench terraces the riser is often reinforced with stones and/or vegetation cover. When the shelf is made slightly inward sloping, water storage increases and soil protection is improved. In arid areas, conservation bench terraces are preferred. In such cases, the distance between terraces is increased and a portion of the sloping land is left to act as catchment area. The runoff generated by the catchment area will nourish the plants placed immediately above the riser wall. This design increases the amount of water available for the plants and reduces erosion.

Geographical suitability: Ideal climatic conditions for the implementation of bench terraces are annual rainfall of 600 mm, depth of soils of 80 cm, high soil permeability, and a maximum slope of 40 percent (embankment consolidated with stones). This type of technique works well on slopes with consolidated and permeable soils. It should never be used on impermeable and friable soils (schist and marl) where risks of landslides are high. Mediterranean bench terraces (with low walls) are found throughout wetter areas, but in arid and semi-arid areas only near springs and seasonal riverbeds.

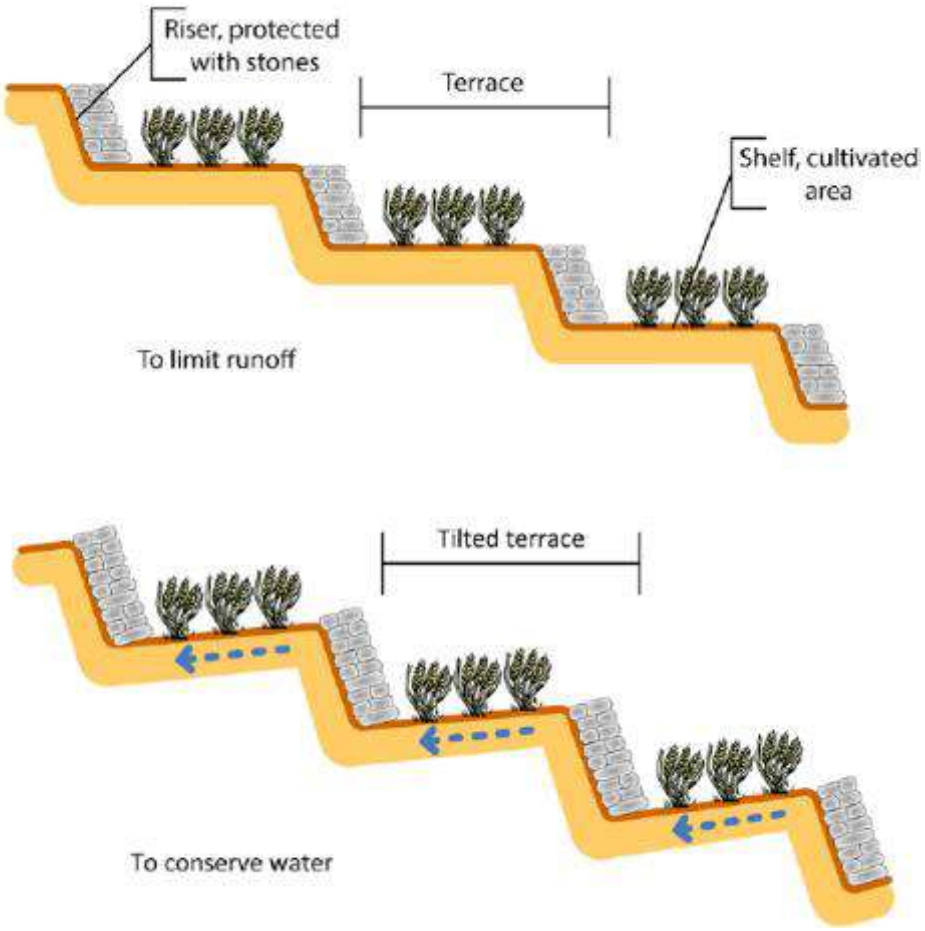


Figure 8-2: Bench terrace to limit run-off (top) and bench terrace with back sloping bench to increase water retention time (bottom)

Technical and environmental factors: Bench terraces reduce water erosion across the slope, reduce river peak flows and siltation of dams. By reducing runoff, these structures are more effective in controlling gully erosion as continuous banquettes that could overflow. In addition, bench terraces promote accumulation of organic matter and nutrients in the soil. They improve soil productivity through the capture and retention of organic particles transported by water.

Socio-economic factors: Generally, the implementation of a terrace requires 350 - 1500 days of work per hectare depending on the type of wall (earth or stone) and the slope. Regarding the maintenance capacity, because bench terraces are a traditional technique with high added value (the soil becomes more profitable in time), farmers have guarded a know-how from generation to generation. However, for terraces requiring a higher investment, farmers may rely on external labour where it is not available within the family. To maintain the efficiency of terraces, regular maintenance of the low wall, especially after each major storm, is required.

Productivity and profitability: Improving land productivity is a motivating factor for the implementation of these structures, particularly in semi-arid areas and on steep slopes (that would otherwise be uncultivated due to water erosion). Organic manure and mineral supplements are applied on bench terraces to sustain the production, which helps to produce

vegetables in rotation with grain and fodder. Irrigation, vegetable gardens and fruit plantations ensure high profitability of this technology

Figure 8-3: Bench terraces

Check dams

A check dam is a small temporary or permanent barrier constructed of rock, gravel bags, placed across a gully, channel or drainage to lower the speed of flows from storm events. Check dams are built using rocks arranged in sequence such that the base of the previous dam is at the same height as the top of the second dam. Stones with a diameter of 10-35 cm are suitable, easily maneuvered by a single person, but large enough not to be dislodged by flowing water. Shale and sandstone should be avoided as they wear away easily. Permanent check dams are built with stones, bricks and cement. Rock check dams should have a notched, “V” or “U” shape with the center portion at least 15 cm lower than the sides to prevent normal runoff from going around the dam, and eroding the sides of the channel. The check dam height is often about ¼ of the base width.

Figure 8-4: Check dams

Flood Control and Water harvesting Structures

Infiltration pit

Infiltration pits are shallow pits that help harvest run-off water in the plantation/field to allow easy infiltration and uniform distribution of water to crops. Suitable for soils with low infiltration capacity, and low water table. The infiltration pit should be constructed at a depth within the root zone of a given crop in place.

A typical infiltration pit is of a standard depth of 0.6 m, width of 2 m and length of 3 m. Grasses will be planted around the pit embankment/bund for stabilization.

Figure 8-5: Infiltration trenches/ pits

Cutoff drains and Percolation pits

Cut off drains are diversion canals that are used to divert run off into the garden. Percolation pits on the other hand are small pits that collect water from cut off drains and drain it into the soils. They are suitable for low lying areas with high levels of ruin-off. During heavy rains the second nature of many roads becomes apparent: they intercept surface runoff and generate streams on their relatively compact surfaces. The location of the road in relation to contour lines, the height of the embankment, the longitudinal and lateral slope of the road, the surface material and the under drainage are all important factors in determining how much runoff is generated from a road and hence how water can be retained. Rainwater can be harvested from the road surface (depending on the type e.g. tarmac, gravel, etc.), whereby the road drainage can be used to convey the water for storage or recharge (see Figure 8-6).

Cut-off drains will consist of a trench of dimensions of 0.6 m width and 0.3 m depth in areas with low runoff while depth increases to 0.45 m where runoff is high with varying length according to location preference on the land. The percolation pit is constructed with dimensions of 0.6 m diameter and 0.3 m depth in areas with low runoff while 0.9 m diameter and 0.6 m width in high rainfall areas.

Figure 8-6: Cut-off drains and percolation pits

Geographical suitability: The technique is very suitable for arid and semi-arid areas where water productivity should be maximized, but also for other areas if combined with reservoirs (to store water for small-scale irrigation) or if the water is infiltrated into the ground to improve soil moisture and replenish ground water. The numerous opportunities in terms of roads spread across the country make water harvesting from roads attractive in all AEZs.

Technical & Environmental factors: Water from roads can either be used to improve soil moisture, or stored in reservoirs and used for various purposes. When water from roads is stored in the permeable reservoirs it can slowly infiltrate into deeper layers of soil, therefore replenishing (shallow) ground water aquifers. Because of the large volumes of water that can be potentially collected per kilometer of road, there is a high chance to harvest and store that water in a reservoir. Road water harvesting also helps in decreasing soil erosion that commonly occurs along drains and below road culverts.

Contour retention ditches/ trenches

Retention ditches are designed to trap and retain incoming runoff and hold it until it infiltrates into the ground. Retention ditches are to be of 0.6 m width, 0.6 m depth and length of 10 m. A tie bud is usually placed every after 10m length to allow free movement of water from one trench to another. This reduces pressure on the embankments which may cause them to collapse. Spacing interval depends on the slope steepness which ranges from 4 to 20m, but it can be on an average standard of 15m

Figure 8-7: Retention ditches

Retention Ponds

Retention ponds can provide both storm water attenuation and treatment. They can be designed to control flow rates by storing floodwater and releasing it slowly once the risk of flooding has passed. Runoff from each rain event is detained and treated in the pool. The retention time promotes pollutant removal through sedimentation and the opportunity for biological uptake mechanisms to reduce nutrient concentrations. Permanently wet ponds can be used to store water for reuse, and offer excellent opportunities for the provision of wildlife habitats.

The stored water will change the water level, and ponds is to be designed to function in both dry and wet weather. Quantity can also be influenced by the amount of water that can be allowed to infiltrate into the ground if there is no risk to groundwater quality. A typical design of a retention pond 30 m by 10 m with a depth of 1 m with a holding volume of 300 m^3. Ponds treat runoff in a variety of ways: like Settlement of solids in still water. Having plants in the water enhances calm conditions and promotes settlement, Adsorption by aquatic vegetation and Biological activity.

Water harvesting ponds can be designed in various shapes, materials and dimensions such as, circular, square and rectangular ponds. Water is collected in the pond by channeling water from surrounding fields, ephemeral streams, paved surfaces (paths, roads), channels (cut-off drains) or naturally sloping surfaces, as shown in Figure 8-8. They are usually constructed near homesteads for easy access. Soils with a high content of clay are preferable for constructing small water harvesting ponds as they have low permeability. Alternatively, the bottom of the pond can be reinforced with cement mortar and wire mesh, paved with rocks, puddled with clay or plastic sheets where needed.

Figure 8-8: Retention ponds

Water harvesting tanks

Water harvested by managing, controlling and making use of rainwater in-situ or within the vicinity of rainfall is termed as rainwater harvesting. Rainwater harvesting, a tank size of 10,000L and 5,000L have been considered given the low population count in the area. It will have a tank stand of 1.2m high with a diameter of 1.3m. If need be, it will have a protective surrounding to help protect the tank from excessive water pressures.

Figure 8-9: Rain water harvesting tank

Run-off harvesting tanks

In this method of collecting rainwater for irrigation, water flowing along the ground during the rains will be collected to a tank below the surface of the ground. The tank is constructed using bricks, which are coated with cement. During storage, it is important to incorporate efficient and effective water conservation methods by reducing evaporation and also by adopting efficient irrigation techniques. It is a very 'easy to adopt' technology proven with many communities in the country that if used properly can be very profitable.

Selecting a location for the construction of a water harvesting tank

- ✓ Collection area
- ✓ The number of users
- ✓ Water usage patterns
- ✓ Observe the direction of the surface flow of rainwater in the land.
- ✓ Proximity to large trees.
- ✓ Climatic conditions
- ✓ The tank should be close to the area of cultivation to ensure ease of irrigation.
- ✓ The tank should not be in close proximity to the house or to paths /roadways as it is possible for children and even negligent adults to fall in. As an additional security measure, construct a fence around the tank.
- ✓ The opening of the tank should be to the direction of the flow of rainfall. It is not advisable to obstruct patterns of natural flow of water as there is a possibility of mud and other waste getting into the tank. (The mud filters function only when the water flows directly through them)

Design and Construction: For Runoff harvesting, a typical tank of 4 m by 3 m of depth 3m is to be established and will vary in size according to site. It will have a sedimentation tank (2 m diameter and Depth 0.6 m) that will help check the silt in the run off prior to entering the tank.

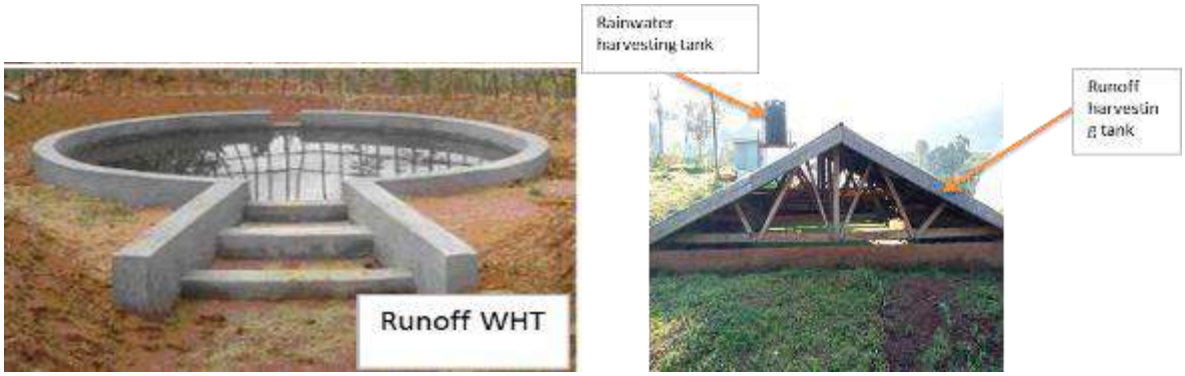


Figure 8-10: Run off water harvesting tank

Classification of Interventions

These interventions suggested have a beneficial role they will play in the reduction of soil and water loss in the downstream areas of the catchment and agricultural landscapes. Additional site specific interventions were proposed during the Stakeholder Consultations and community engagements and a list of prioritized interventions was developed. Interventions have been sub-divided into four different groups i.e. floodwater harvesting (Flood WH), Macro-catchment Water Harvesting (Macro WH), Micro-catchment Water Harvesting, and Rooftop Water Harvesting (Rooftop WH) as illustrated Figure 8-11 below.

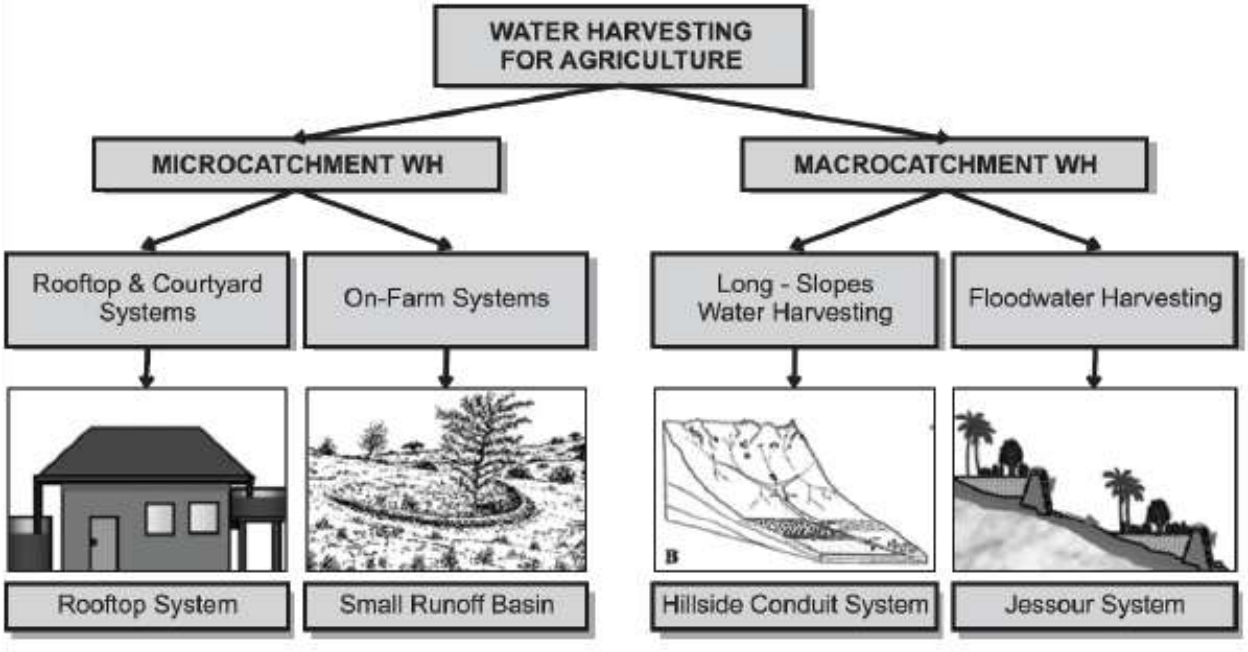
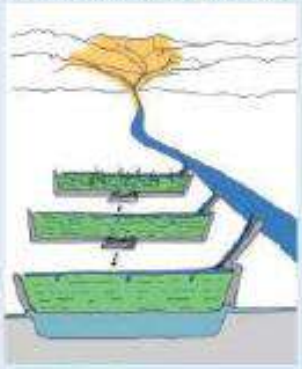
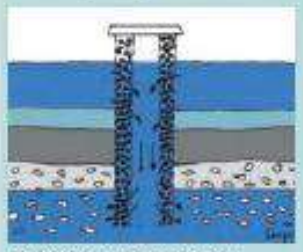
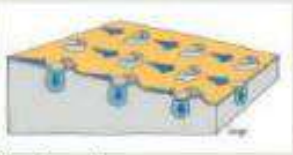
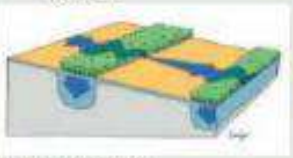
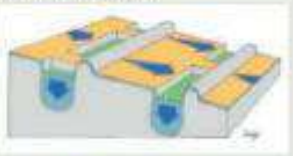


Figure 8-11: Overview of the most likely interventions

(1) Floodwater harvesting (FloodWH)	(2) Macrocatchment WH (MacroWH)	(3) Microcatchment WH (MicroWH)	(4) Rooftop and Courtyard WH (Rooftop-Courtyard WH)
Flood recession farming; Inland valleys; Floodwater diversion, off-streambed: – spate irrigation, – floodwater spreading bunds;  Spate irrigation **Floodwater harvesting within stream bed:** – riverbed / *wadi* and gully reclamation: e.g. *jessour, tabias*, "warping" dams, – permeable rock dams  Riverbed reclamation	**Water storage in soil:** – hillside runoff / conduit, – foothill reclamation: e.g. *limans*, – large semi-circular or trapezoidal bunds, – road runoff, – gully plugging / productive gullies, – cut-off drains (redirection of water); **Water storage facilities:** Surface storage: – natural depressions, – ponds and pans, – excavated ponds (e.g. *hafirs*), – cultivated reservoirs / tanks, – ponds for groundwater recharge, – surface dams: small earth and stone dams, check dams, rock catchment masonry dams; Subsurface storage: – subsurface, percolation and sand dams, – subsurface reservoirs: cisterns;  Macrocatchment systems **Traditional wells:** – horizontal wells, – recharge / injection wells.  Recharge / injection well	**Pits and basins:** – small planting pits: e.g. *zaï / tassa*, – micro-basins: e.g. *negarims, meskats*, small semi-circular bunds, eyebrow terraces, mechanised Vallerani basins;  Planting pits  Semi-circular bunds **Cross-slope barriers:** – vegetative strips, – contour bunds and ridges, – tied ridges, – stone lines and bunds, – contour bench terraces (e.g. *fanya juu*),  Vegetative strips  Contour lines and trenches	**Catchment:** Roofs Courtyards: – including surfaces of rock, compacted earth, sealed or paved surfaces, – plastic sheets, corrugated iron sheeting; **Storage:** – tanks, – reservoirs, – cisterns.  Rooftop WH  Courtyard WH combined with rooftop WH

Other interventions shall include

a) Sand bags
b) Mulching
c) Agroforestry

Multi-Criteria Analysis

Prioritization of options/ structures/ interventions was instrumental and was derived using the MULTIPOL method as Multiple-Criteria Decision-Making (MCDM). The approach provides a mechanism for the screening of structures by the selection of weights against geographical suitability, technical and environmental suitability, social-economic suitability, agricultural productivity and profitability impact screening criteria. Options were evaluated against a defined set of criteria, based on available information, which reflect the purpose of the assignment. A score of between 0 and 5 was assigned to each indicator, where 0 represented unsatisfactory and 5 represented fully satisfied. The final scores assigned to the criteria for each technique represent the mean of scores given for each of the indicators within that criterion.

The development of an options matrix involved several steps, as follows:

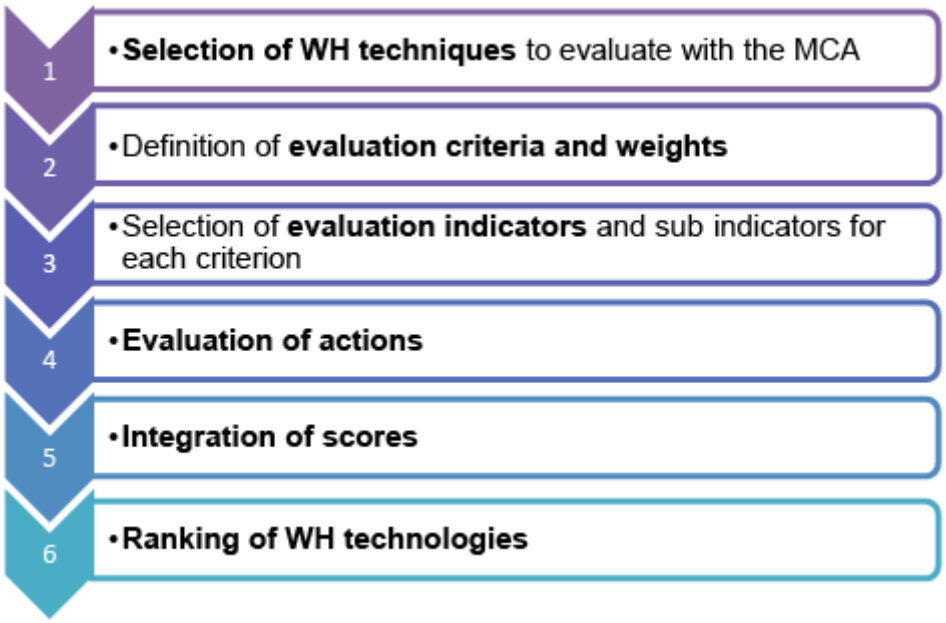


Figure 8-12: Steps of Multi-criteria analysis (MCA)

Table 8-3: Criteria and associated indicators used in the MCA

Criteria	Indicators	Description
Geographical suitability	Agro-ecological zones (AEZ)	Intervention potentially applicable in a wider variety of AEZ within a given catchment received a higher score
Technical and environmental suitability	Storage type	A measure of the potential of each intervention to increase the water buffer at landscape scale. i.e its contribution to the hydrological cycle
	Storage capacity	A measure of the volumes of water that can be stored by a specific

Criteria	Indicators	Description
		intervention. It applies only to water storage in open or closed reservoirs
	Sediment trapping efficiency	A measure of the amount of trapped sediment that can be stored by a specific intervention.
	Water and soil quality	A measure of the positive impacts of each intervention on water and soil properties (Physical, chemical, biological) and against soil erosion
Socio-economic suitability	Multiple uses of water	A measures of the use of water stored by a certain intervention. Techniques that contribute to more uses received a higher score
	Costs	Consider investment, operation and maintenance costs (often expressed in labour requirements) for each technique and attaches a lower value to those techniques having higher costs
	Management and maintenance capacity	Provide information on the availability of local expertise and capacity to maintain and manage the intervention
	Gender	A qualitative assessment of the implications of the different intervention for both men and woman. For instance, techniques that increase workload of women or favour men more than women score lower
Agricultural productivity and profitability impact	Productivity	A measure of the quantitative increase in crop yields compared to control (same crop without the adoption of the intervention)
	Diversification	A measure of the extent to which agricultural production can be diversified (also introducing higher value crops) thanks to the adoption of the technique
	Profitability	Inform on the relation between revenue obtained or anticipated by the farmer (long-term) and the resources deployed to obtain the revenue

Evaluation criteria were pre-selected and weighted on the basis of the level of importance in determining the suitability of interventions according to literature review. The four criteria and their associated weights are presented in Figure 8-13. Greater weight is given to the agricultural productivity in the calculation of the overall performance of each technique.

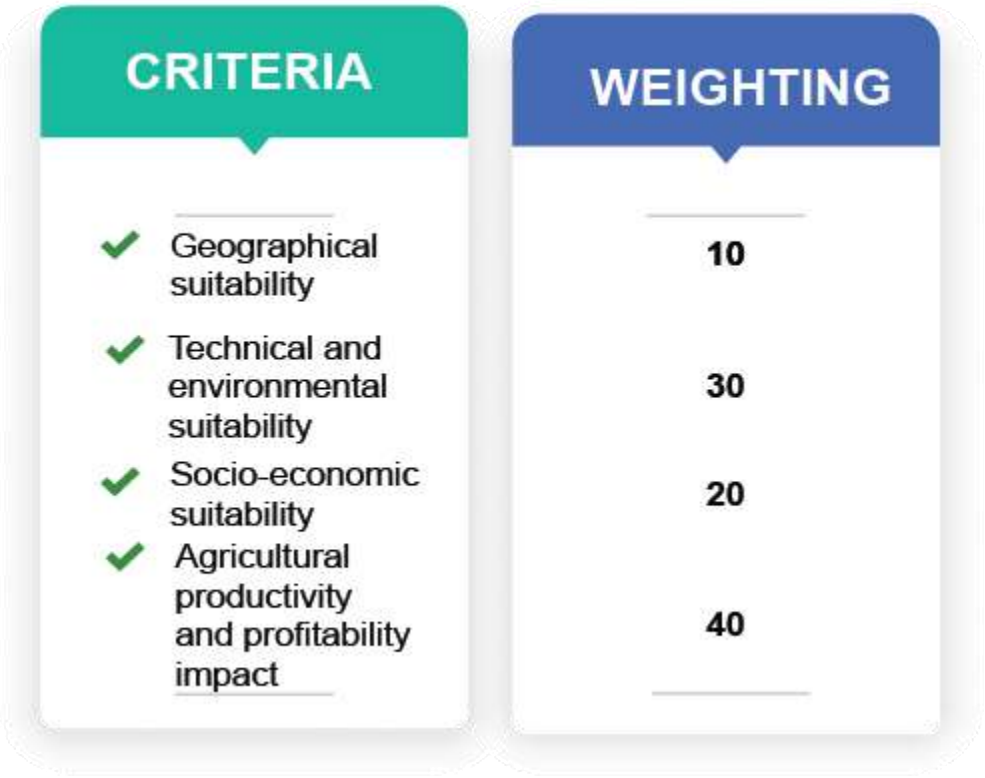


Figure 8-13: Criteria used for evaluation

The MCA evaluated the 30 most common and effective water harvesting, flood control and biophysical structures in the assessed potential areas, as outlined below. Performance of the structures was found to range from 54% to 90%, 19 structures scored above 70%. The standard deviation of criteria scores varied greatly between techniques. The top 14 performing interventions (i.e. above 80%) (Spate irrigation, Floodwater spreading bunds, Road runoff, gully plugging, cut-off drains, Ponds and Pans, Excavated retention ponds, surface dams, Subsurface percolation and sand dams, Subsurface reservoirs cisterns, contour bunds, contour bench terraces, rain water tanks, and surfaces of rock) and their associated scores are shown in Table 8-4. Flood control, water harvesting and biophysical structure measures are commonly coupled with agronomic and forestry practices such as planting trees, managing soil fertility and enhancing soil water infiltration and retention capacity.

All proposed measures can be used as stand-alone measures, but to create an improved water buffer they work at best when integrated with each other with high density and at

landscape scale. Such an approach, known as 3R[4] solutions, can be applied in diverse environments in hilly areas but also in flat flood plains.

Table 8-4: MCA results for top performing structures

Structure	Criteria*				Weighted Performance Score
	A	B	C	D	
Floodwater spreading bunds	3.67	4.25	4.30	4.33	84.70
Road runoff: diversion channels	3.33	3.67	4.70	4.33	82.13
Gully plugging	4.33	4.17	4.75	4.00	84.67
Cut-off drains	3.67	3.92	4.70	4.33	84.30
Ponds and pans	4.00	4.17	4.40	4.67	87.93
Excavated retention ponds	3.67	4.67	3.80	5.00	90.53
Ponds for groundwater recharge	4.00	3.67	3.85	2.33	64.07
Surface dams: Small earth and stone dams, check dams, rock catchment masonry dams	4.00	4.08	4.40	4.33	84.77
Subsurface percolation and sand dams	4.67	4.33	4.80	4.33	89.20
Subsurface reservoirs cisterns	4.33	3.58	4.30	4.67	84.70
Contour bunds and ridges	4.67	4.25	3.55	5.00	89.03
Contour bench terraces: Fanya juu	1.67	4.50	3.20	4.67	80.47
Tanks, reservoirs and cisterns	4.00	3.25	4.60	5.00	85.90
Surfaces of rock	4.00	3.33	4.40	4.33	80.27

*A – Geographical suitability, B – Technical and environmental suitability, C – Socio-economic suitability, D – Agricultural suitability and profitability impact

Measures such as excavated retention ponds, contour bunds and ridges emerged as the strongest technologies in the MCA, scoring consistently high across all four criteria. These measures have great scope in flood control and providing supplementary water for domestic and agricultural production in the catchment during the dry season, as well as during the common dry spells in the wet season. Nevertheless, in accordance with the 3R approach

[4] 3R stands for "Recharge, Retention and Reuse" of groundwater and rainwater. 3R is an initiative of four Dutch entities (RAIN, Acacia Water, MetaMeta and Aqua for all) that emphasizes the benefit of collecting water, extending the chain of water use and reusing water as much as possible within a catchment. More information can be found at: http://bebuffered.com/

outlined previously, it is advised to combine these measures in a system together with techniques that favour soil moisture retention, soil fertility and plant health. Consequently, measures such as contour bunds and bench terraces, which also performed well in the MCA, can enrich the farming system and help to increase rain-fed production. The use of mulching as part of a landscape wide WH system would also be beneficial and enable further increase in soil moisture storage.

Table 8-5: Sustainable land and environmental management implementation costs

Structure	Unit costing (USD)	Quantity	Total Cost
Floodwater spreading bunds per ha	185	4	740.00
Road runoff: Diversion Channels	90	10	900.00
Gully plugging	98	5	490.00
Cut-off drains	50	10	500.00
Ponds and pans	11.5	5	57.50
Excavated retention ponds	5,000	2	10,000.00
Ponds for groundwater recharge	64.07	4	256.28
Surface dams: Small earth and stone dams, check dams, rock catchment masonry dams ($/m^3 storage)	500	15	7,500.00
Subsurface percolation and sand dams ($/m^3 storage)	17.2	2	34.40
Subsurface reservoirs cisterns per m^3	440	2	880.00
Contour bunds and ridges per HA	75	30	2,250.00
Contour bench terraces: Fanya juu per HA	465	30	13,950.00
Tanks, reservoirs and cisterns ($/m^3 storage)	230	15	3,450.00
Surfaces of rock ($/m3/d)	350	1	350.00
Total Cost			**41,358.18**

Agro-forestry

Responsible management of planted forests consists of interactions with local communities, agriculture, animal husbandry, indigenous forest and agroforestry land uses. Engagement with involved stakeholders (e.g. local community) in planning, managing, monitoring and use of the forests, allows to avoid conflicts on land use and educate them to sustainable exploitation of forests.

Charcoal burning and wood fuel, the main source of energy for both rural and urban people, is an uncontrolled practice in Lower Muyembe Micro-catchment with the consequent deforestation and destruction of natural ecosystems.

Measures to be implemented in CRAP include:

- Establish a team responsible for forest protection and management;
- Develop an integrated decision – making and multi stakeholder approach to avoid land use conflicts;

- Train stakeholders on forest, soil and water conservation;
- Train stakeholders on the renewable energy resources e.g. biomass and hydro energy, including promotion of plantation of forests for biomass production in order to avoid that charcoal is produced from indiscriminate tree cutting;
- Establish a program aimed to restoring lost woodland and to ensure the maintenance of environmental sustainability and forest health (e.g. adoption of integrated pest management approach, control the diseases, reduction of incidence and impact of invasive species).

Table 8-6: Investment Costs for Agro-forestry

Action	Sub-counties	Description of Intervention	Quantity	Unit	Rate (USD)	Total Amount (USD)
Planting of trees in degraded areas	All the nine sub-counties	Procure 9000 seedlings	9,000	Seedlings	10	90,000
		Plant 3 tree nurseries	3	beds	1,000	3,000
TOTAL						**93,000**

Maintenance cost shall be covered by the land owner. It is assumed that the trees shall require extensive maintenance for one year after which the cost will decrease considerably. The maintenance cost estimated here covers one year and include 1st and 2nd weeding just around the tree and other miscellaneous costs that might arise.

River Bank Protection and Stabilisation

Bank protection structures represent a widespread typology of hydraulic works along the river course. Their construction is usually planned along torrent stretches with bank erosive problems that can produce instability conditions both on natural, artificial banks and on steep slopes. Strong protective structures like gabion walls (Photo 8-1) are usually put in practice for straightening works or planimetrical modification of the river course, or in combination with other hydraulic structures (bridges, dams, etc). In many cases, the construction of strong bank protection structures is required to stabilize landslides. Construction of this kind of interventions causes a substantial modification of the natural aspect of river banks with the partial or complete destruction of the ecological conditions and the reduction of the biological diversification of the riparian habitats.

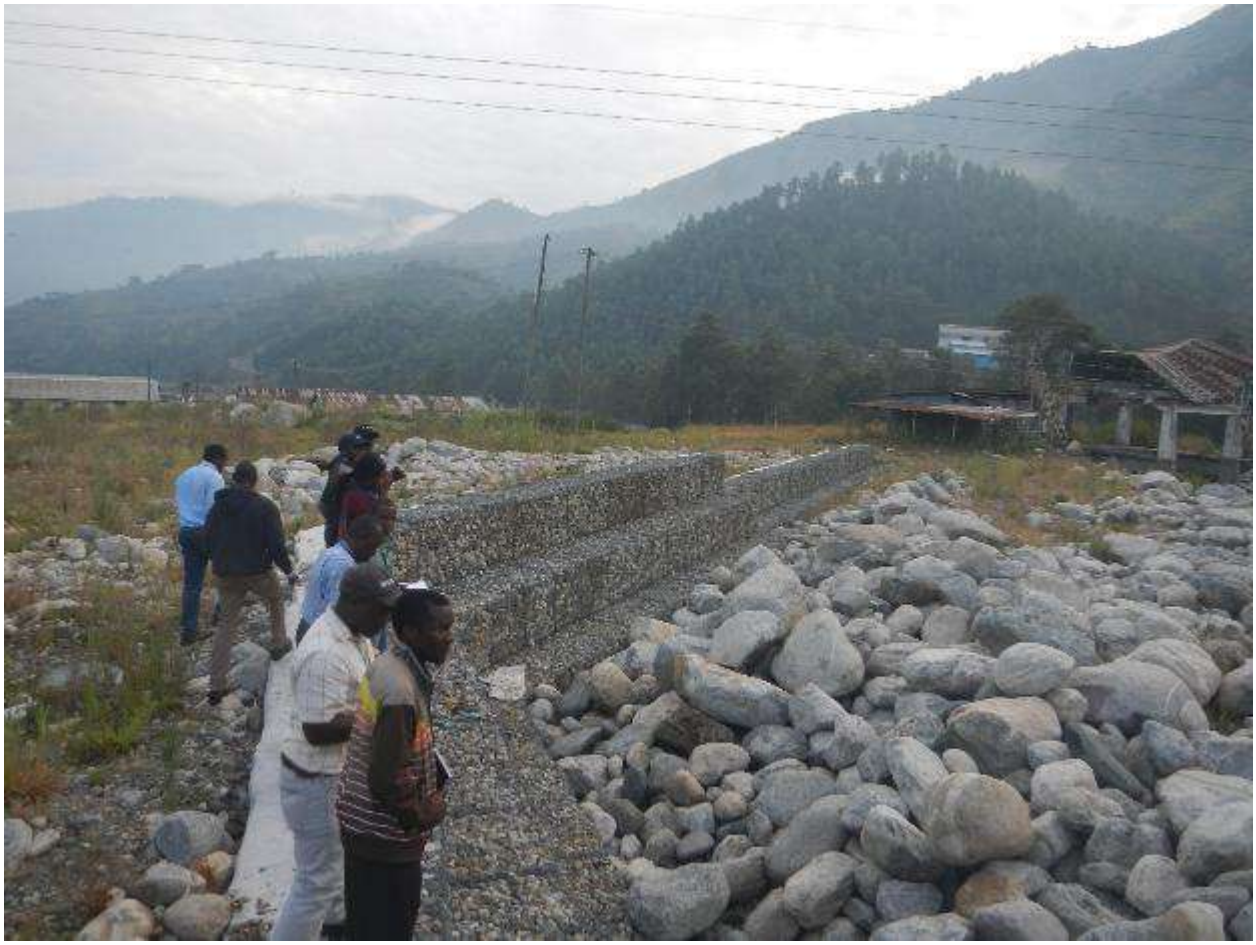


Photo 8-1: Gabion walls used to stabilise the river and protect the banks

Table 8-7: Investment costs for River bank protection and stabilisation

Action	Sub-counties	Description of Intervention	Qty	Unit	Rate (USD)	Total Amount (USD)
River bank protection and stabilisation - gabions, management of cattle access points, protection of riparian vegetation	Muyembe, Nabongo, Gibuzali, Sirimityo	Construction of Gabions	5	km	17,857	89,285
		Demarcations on rivers	5	km	510	2,550
		Delimitation of buffer zones	10	ha	400	4,000
		Recourse of river	3	km	35,714	107,142
		River pegging	10	km	250	2,500
		Put in place woodlots	5	Ha	3,372	16,860
		Plant riparian vegetation, 150 km (4 m wide)	30	Ha	867	26,010
		Procure seedlings	16,000	seed lings	0.1	1,600
					Total	**249,947**

Flood mitigation options

The effects of various flood mitigation measures can be analyzed based on their environmental and socio-economic impacts. A fieldwork was conducted after the recent flood of November 2024 to collect some pieces of evidence on the flood extent in the area, major damages and hotspots and also to validate the flood model results. The dangerous flood events of this river caused considerable losses, such as damages to concrete bridges, Feeder roads within the districts linking villages plantations and residential structures.

Option I: Community/property relocation and small-scale channelization

This involves moving the community and their infrastructure outside the flood hazard areas identified through mapping inundated flood extents. The number of community properties falling within the inundate area was indicated considering the natural river flow without any modification.

Option II: Levee construction

A levee is an earthen embankment supported by Gabion-type revetments and riprap; it is constructed on the sides of the river bank adjacent to the hotspot (community property & residential) area. It has the capability of withstanding the design flood if flow characteristics at selected cross sections of the river reach are well analyzed and considered for design. For this reach, levees seem to be more practical solution for reducing flood damage because of the availability of materials (stones). Dimensions of the levee considered have an average elevation of 8m for the entire reach length. Riprap revetment with an additional foundation scour depth in form of a steep slope in the riverside to prevent any limitation in the cross-sectional area of the river channel may be used for the downstream river section where the channel slope, stream power and flow velocity are generally low.

Option III: Channel modification/Channelization

This is based upon the idea of widening and deepening of the river channel by dredging (silt removal), this will provide a substantially larger channel with a capacity of allowing a greater volume of water to flow downstream without causing any impact on the adjacent flood plain. Natural bends along the river reach can maintained since the river straightening may cause negative erosion effects on the river banks downstream. Three alternative sections of different channel dimensions were considered in analysis as presented below;

Table 8-8: Proposed channel modification dimensions for the river reach

Scenario	Bottom width (m)	Depth (m)	Section	Slope (H: V)
1	100	15	Trapezoid	2
2	100	20	Trapezoid	2
3	60	20	Trapezoid	2

HEC-RAS model runs for the three alternatives was performed to check capacity and effectiveness of each proposed section. The three alternatives have enough capacity to convey the river peak flows of up-to 200yr return period except alternative three with unacceptable velocities for flow peaks of 100yr and above. This measure (**option III**) may be

adopted for the whole river channel length with the above proposed dimensions applying to different sections.

Rural Water Supply and Sanitation Schemes - Gravity Flow Schemes

The main technology options used for water supply improvements in rural areas in Uganda include deep boreholes (44%), shallow wells (24%), and protected springs (21%). Others include tap stands/ kiosks of piped schemes and rainwater harvesting tanks (11%). As of June 2018, the national safe water coverage in rural areas was estimated at 70%. There was no change in coverage from that of June 2017. Out of the 57,974 rural villages in Uganda, 38,183 (66%) of the villages had valid water sources as of June 2018. (MWE, Sector Performance Report 2018).

The Rural Water Supply sub-sector is defined to include all those areas under the jurisdiction of District Local Councils and Rural Growth Centres, but excluding those urban areas governed by Town Boards, Town Councils, Municipalities and Cities. In practice this means that rural water supply covers those communities and villages with populations up to 1,500 and Rural Growth Centres (RGCs) with populations between 1,500 and 5,000.

Rural Water Supply and Sanitation Services

Vision 2040 goal is to have 100 percent of the population with access to safe piped water by 2040. The Second National Development Plan (NDP II 2015/16-2019/20) targets to increase access to safe water from 65 percent to 79 percent in rural areas by 2020. As of the 2018 Water and Environment Sector Performance Report (MWE 2018), national safe water coverage for rural areas was estimated at 70%. Access to basic rural sanitation reduced to 79% in 2018 from 80% by June 2017. The functionality for rural water supplies remained the same (85%) as previous year 2017.

Fortunately, the Strategic Sector Investment Plan (SSIP 2018-2030) sets the investment priorities for the sector for the period between 2018 and 2030. The SSIP focuses on five areas of; village water supply, functional rural water sources, improved drinking water, safely managed drinking water and cost per capita. Over the next five years within which this project is expected to be completed and commissioned i.e. 2019/2020 to 2023/24, the targets for the above five priority areas up to 2024 for a moderately low funding are; village water supply (100%), functional rural water sources (95%), improved drinking water (84%), safely managed drinking water (13%) and cost per capita ($65).

The Water and Environment Sector will prioritize increasing access to safe water, increasing sanitation and hygiene levels and increasing functionality of water supply systems, incorporate gender analysis, implement water resources management reforms and promote catchment-based integrated water resources management.

The sector targets to increase water supply coverage in rural areas from 70% in June 2018 to 84% by June 2024 by ensuring that at least each village has a clean and safe water source; and by ensuring functionality and effective use of the water supply systems to at least 95% (SSIP 2018-2030). Safely managed drinking water will not be achieved even with moderately high funding to the sector. In a bid to increase safe water coverage, the sector intends to adopt a policy shift from the use of point water sources to introducing piped water supply systems in the medium and long term, which is expected to be sustainable and will address water needs for both rural and urban areas. This policy shift will include:

- Development of large gravity-fed piped water supply schemes with river-based sources in mountainous regions to serve large areas across district boundaries, or motorized piped water schemes from surface water sources such as lakes and rivers to supply the underserved communities in rural areas;
- Promotion of integrated rainwater harvesting intended to cover water needs for human consumption, small cottage agricultural processing industries, small scale irrigation and water for livestock at household level; surface runoff harvesting using dams will also provide water for rural areas;
- Development of solar-powered mini-piped water schemes to supply more persons that otherwise would be served using point sources with hand pumps.
- Promotion of appropriate technologies by undertaking action research and development to identify suitable water supply and sanitation technologies for specific areas. The appropriate technologies are not limited to low cost technology but cover all service levels.

Priorities for Rural Water and Sanitation

The National Development Plan II (NDP II) is the current running plan and development framework of Uganda, derived from Uganda's vision 2040. The NDP II has 4 development objectives among which objective number 3 is to "Enhance Human Capital Development" under which development indicator number 10 the safe water coverage baseline and targets are defined. The NDP II envisions that safe water coverage in rural areas should reach 79% by 2020 and eventually to 100% by 2040 as envisaged by vision 2040.

Relatedly, Uganda's Strategic Investment Plan for the Water and Environment Sector (2018-2030) has the strategies and objectives projected to 2030 (see Table 8-9 below) and derived from Vision 2040 and the foregoing NDP II (2015/16 – 2019/2020).

Table 8-9: Rural Water Supply and Sanitation Objectives and Strategies as in SSIP

Objective	Strategies
Objective 1: By 2030, access to safe and affordable water supply in rural areas has increased 100%, in order to progressively fast track achievement of coverage for all including men and women.	***Strategy 1:*** Construct, operate and maintain appropriate and climate change resilient community water supply systems in rural areas.
	Strategy 2: Improve functionality, sustainability and resilience of water supply systems in rural areas to provide safe water all-year-round and reduce the number of people suffering from safe water scarcity.
Objective 2: By 2030, access to improved sanitation has increased to 100% for households in rural areas, paying special attention to the needs of women and girls and those in vulnerable situations.	***Strategy 1:*** Promote improved sanitation and hygiene practices in households, communities and rural growth centres in order to reduce the number of deaths and illnesses related to poor sanitation.

Waste Management Facilities

Faecal Sludge Management Facility

Background

Water sanitation systems development and sludge management are core components of IWRM approach considered in Lower Muyembe Micro-catchment. It is important to take into account both the aspect of encouragement and promotion for adoption of improved private sanitation facilities and the aspect of improvement of infrastructures for public service. Thus, proper technologies are required to deal with both these two aspects that need to be addressed, namely:

- On-site sanitation: ventilated improved pit (VIP) latrines, Eco-San latrines and flush latrines with septic tanks;
- Central sewerage systems: sewage discharge from water closets and other liquid waste flows along a system of sewer pipes to a treatment plant/system.

Ecological Sanitation (or "Eco-San") is the name given to a group of latrine types the common feature of which is that human excreta is treated as a resource. Human excreta are processed on site and then, if necessary, further processed off site until they are completely free of disease organisms. The nutrients contained in the excreta are then recycled by using them in agriculture.

There are three ways to recover the resources in urine - diversion, separation and combined processing.

- Diversion is when urine is diverted away from faeces - they are never mixed with each other and the faeces are dehydrated.
- Separation is when urine and faeces are initially mixed together then separated from each other for re-use.
- Combined Processing is when urine and faeces are mixed together, processed together and their resource value is captured together.

Based on experience in other parts of the country the most common form of Eco-San is the urine diversion type. As Eco-Sans do not require a pit they can therefore be cheaper and more suitable than pit latrines in areas of the Town where pit excavation is difficult; e.g. areas with poor soils, high groundwater or rocky ground

The local communities shall be encouraged to construct Eco-San toilets rather than traditional pit latrines, which have many disadvantages and are more difficult to empty. Besides an improvement of private facilities, it is important to provide also public facilities for public places like churches and Healthy centres.

The choice of faecal sludge treatment unit is dependent on the characteristics of the generated sludge and on the objectives of the treatment process. Faecal sludge characteristics are different from those of waste water, especially its high solids and organic pollution concentrations as well as its high pathogen content. Its characteristics vary widely within and between areas. They are dependent on, among others, the type of on-site sanitation facilities in use and the sludge emptying technology. It can therefore be concluded that FS cannot be considered as a kind of wastewater and that its treatment schemes should be specific.

In industrialised countries, various technologies have been developed for faecal sludge treatment, especially with regard to stabilisation, dewatering and drying of sewage sludge at wastewater treatment plants. Frequently used technologies include extended aeration, anaerobic digestion, mechanically stirred sludge thickeners, centrifuges, belt presses, vacuum filter presses, heat drying, pasteurisation and others. All these technologies require energy sources, highly skilled operators, and chemicals making them very expensive in investment and operation & maintenance. These advanced treatment technologies are therefore not considered as suitable and sustainable options for the treatment of faecal sludge in the catchment and will not be described in the pre-feasibilities.

Only treatment technologies presently in use and recommended from experiences in developing countries will be considered. However, knowledge about these treatment technologies is still limited and most experiences with specific treatment process are available from only a few treatment units or are even only at the level of pilot treatment plants.

In particular, total lack or inadequate treatment of faecal sludge (i.e. untreated faecal sludge indiscriminately disposed into drainage ditches, open spaces and inland waters), as it happens currently in the Catchment, leads to:

- Health related impacts (the excreta may contaminate food or water);
- Impacts on soil (salts, heavy metals, persistent organic compounds, and nutrients are relevant substances in terms of environmental impact on soil (*WHO,2006*);
- Impacts on water bodies (e.g. nutrients in faecal sludge may percolate to groundwater if applied in excess or if flushed into surface water after severe rainfall (*WHO,2006*);

Overview of Faecal Sludge Treatment Options

Faecal sludge treatment can basically be categorized into 2 main processes: - **with** and **without** solids-liquid separation.
The following Figure 8-14 gives an overview of low-cost options for the treatment of faecal sludge on the basis of this distinction.

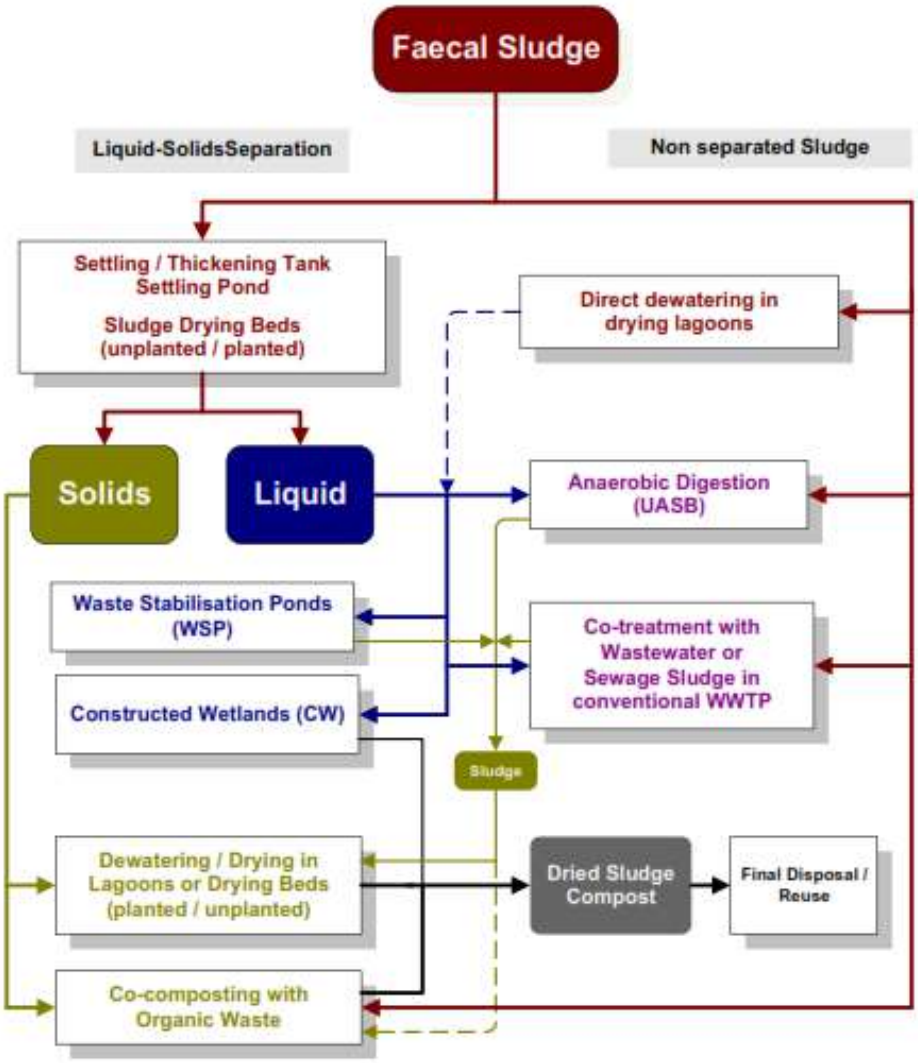


Figure 8-14: Overview of options for Faecal sludge treatment

The settling/thickening tanks and especially the unplanted sludge drying beds require continuous sludge removal, whereas the sludge of unplanted drying beds has only to be emptied every 3 to 5 years. As afore explained, low cost technology options are the key to achieving a sustainable faecal sludge treatment plant. The planted sludge drying beds, with their low Operation & Maintenance requirements and costs, meet this key criterion.

In addition, the bio-solid removed from the planted sludge drying bed is already stabilized and can directly be reused for agricultural purposes. This implies that the post-treatment stage for the solids is not necessary and only the liquid fraction will require post treatment. Considering the above presented advantages, in comparison with the other primary treatment options, it is recommended that planted sludge drying beds are used in the primary treatment of the solids-liquid separation.

Summary of Recommended Faecal Sludge Treatment Concept

The recommended faecal sludge treatment process is as follows:

- Pre-Treatment: - Screening and Grit removal

- Primary Treatment for Solids-Liquid Separation: Planted Sludge Drying Beds for solids-liquid separation, followed by hygienisation of the faecal sludge.
- Post-Treatment of Liquid fraction: Horizontal Rock Filters and Vertical Flow Constructed Wetlands.
- Disposal of Effluent / Reuse of treated Solids.

The following figure shows the selected treatment process:

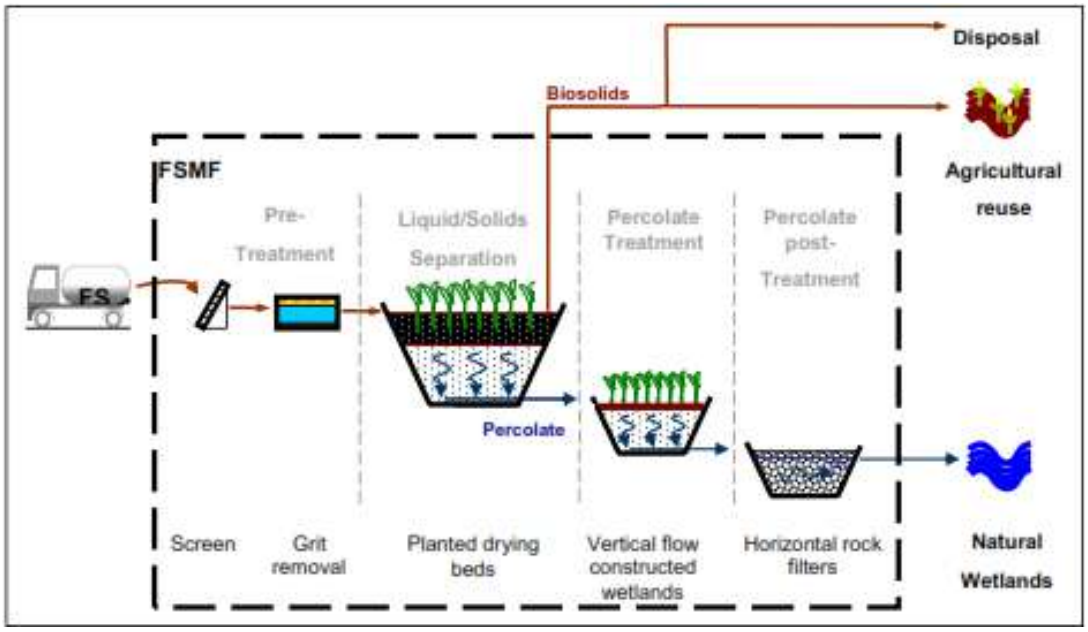


Figure 8-15: Typical/ recommended Faecal Sludge treatment processes in Lower Muyembe Micro-catchment

Investment Costs

The capital investment cost estimates have been calculated for the FSMF taking into consideration the unit rates and those derived from first principles on the basis of current market prices for materials, labour costs, profit, etc. in the country.

Solid waste management

Within Lower Muyembe Micro-catchment, many rural areas do not have universal access to basic infrastructure services, including those related to solid waste. From the situational analysis, majority rely on dig a hole (60.4%), burning (10.1%), communal dump (28.2%), and backyard (1.3%) for waste disposal. Consequently, the analysis results revealed that generation of solid waste in these rural communities reaches 0.5 kg/person/day. Organic matter represents 56 % of domestic solid waste generation and is mainly reused to feed animals. Inorganic solid waste (44 %) is either reused, burned or inadequately dumped in open sites. Based on these data, the annual production of solid waste is 674 tons per year in these communities. Since infrastructure services are virtually non-existent in this rural context, even this amount of solid waste may have a serious environmental impact, with negative effects on the population's health, particularly in terms of hazardous waste.

Foot Bridge

Much rural travel across takes place on local paths, tracks and village roads. These provide essential access to water, firewood, farm plots and the classified road network. Communities and/or local government are generally responsible for this network of paths and tracks. One of the main problems they face is in providing effective water crossings. Particularly during a flood event in the wet season, the lack of an adequate crossing can prevent access to services, or detours of many km or taking risks, especially by women and children, on an unsafe crossing.

To provide safe and sustainable crossings, those providing technical assistance to local government and communities need simple, easily applied guidelines on the selection and construction of effective water crossings. A manual, 'Construction and Improvement of Footpaths and Tracks, contains information on simple water crossings and an introductory chapter on footbridges but within the context of the manual it was not possible to provide the comprehensive guidelines needed for selecting and constructing footbridge designs for specific applications.

Before beginning the selection process, it was necessary to confirm that a footbridge is the best investment option for the water crossing. Other options include:

- For shallow crossings, simple stepping stones may be adequate
- For narrow crossings, a culvert may be a better option
- For wide crossings, a ferry may be the most practical option
- For low pedestrian traffic, a cable way may be the cheapest option

Installation of a footbridge is usually a considerable undertaking, particularly for communities, and it is essential to make sure that it is really needed and is a top priority and commitment for the communities involved.

A site survey was undertaken to decide on the alignment of the footbridge and determine its specifications in terms of span (length between supports) and the traffic to be carried. Detailed construction and installation guidelines will be provided at feasibility stage on a number of options that are considered the most appropriate. The information is presented largely through pictorial sketches with brief notes of explanation.

The types of designs included are:

a) Bamboo bridges
b) Timber log and timber pole bridges
c) Sawn timber, beam and truss types – glue-laminated designs are also briefly described but are not considered appropriate for this manual
d) Steel beam and truss types
e) Reinforced concrete footbridges
f) Suspended and Suspension bridges.

The choice of location will try to minimise the cost of the footbridge and the work involved in installing it and maximise the benefits to the communities that will use it. The selection process

considers the overall installation covering both the bridge and the approach paths or tracks. The following factors are considered:

- Using the shortest possible span (length) of the bridge taking into account the factors below
- Installation on a straight section of the river or stream, away from bends where erosion can occur.
- Selection of a location with good foundation conditions for the abutment supports for the footbridge
- A location as close as possible to any existing path or track alignment
- The location that provides good clearance against flooding and minimizes the need for earthworks on the approaches to raise the level of the bridge
- The stream/river section with a well-defined and stable flow path with little risk of this changing due to erosion of the banks
- Across well-drained ground to minimise problems of water-logging and erosion
- The location as sheltered as possible to minimise wind problems
- The site that allows good access for materials and workers.
- It is helpful if there is a good local supply of materials that might be used in the construction such as sand and stones.

Footbridge Design Loads

The users of the bridge and expected traffic levels were clearly identified as these will determine the required deck width of the bridge and the 'live' loading on the bridge. Although termed "Footbridges", in developing countries like Uganda these rural infrastructures may be required to also carry livestock, pack animals and a range of simple vehicles (Intermediate Means of Transport, IMT) such as bicycles, handcarts, animal-drawn vehicles (ADVs), and motorcycles. This need must be clearly defined.

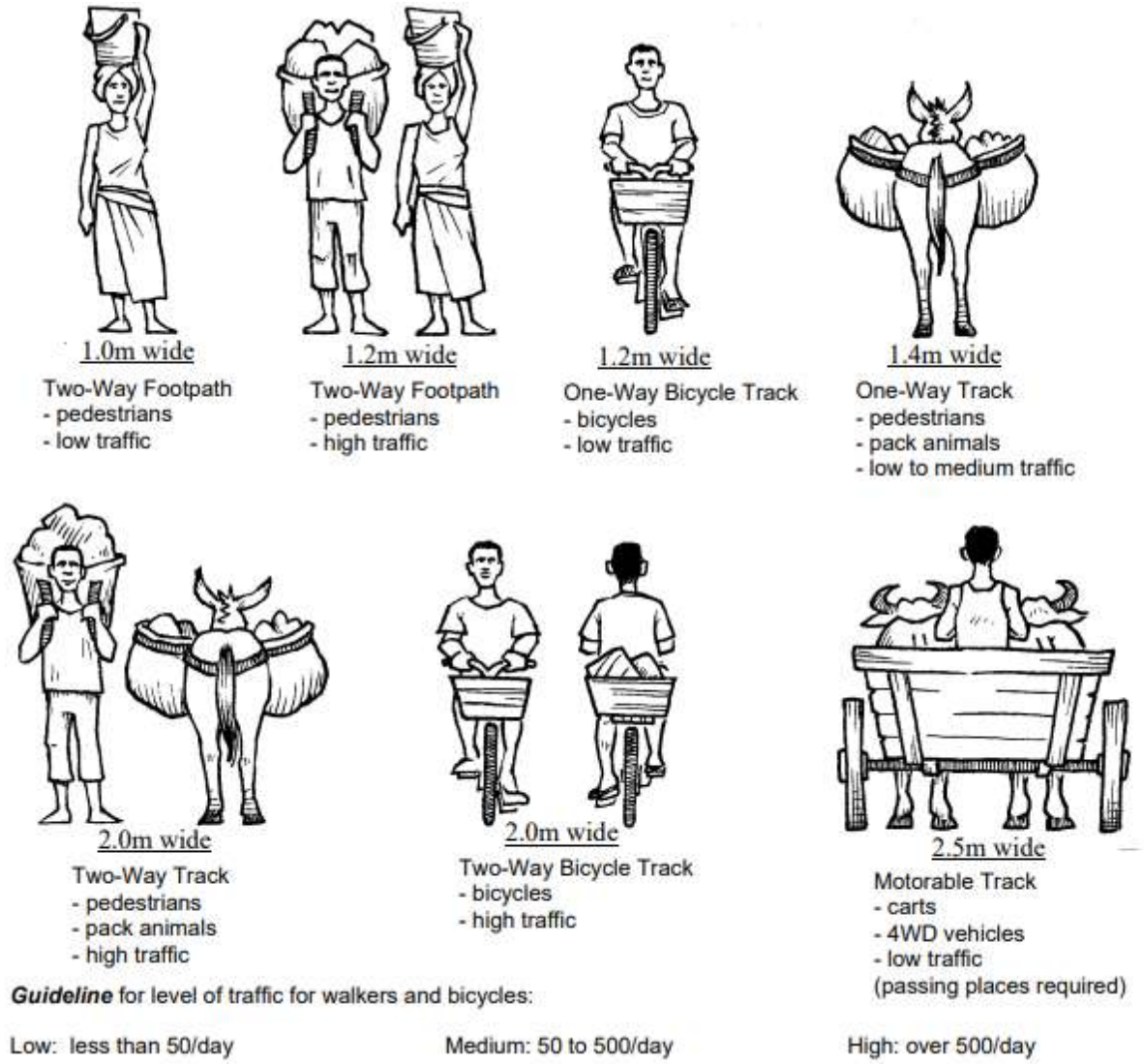


Figure 8-16: Considered standard widths for footbridges

The design conditions to be used for the bridges are listed as follows:

1. Prestressed concrete three-span cable-stayed bridge for a total bridge length of 150 m and 120 m for 1 and 2 respectively
2. The structures will be the semi-underground beam type.
3. The structure will be provided with straight Pylons.
4. Spread type of footing will be used for the foundations.
5. Cast in Place Concrete Pile with Steel Casing for foundations will be used on all the piers

Evaluation of individual sub-items will be scored accordingly, described hereafter as follows: 1 (inferior to other alternatives), 3 (moderate) to 5 (superior to other alternatives). The scoring will then be weighted by factors derived from stakeholders' remarks.

8.3.3 Number of Beneficiaries

Lower Muyembe Micro-catchment is estimated to have a population of approximately 123,000 people by 2035 referring to the Uganda's growth rate by UBOS 2024 census. Thus, rehabilitation of the micro-catchment is expected to directly benefit the present and future population. It is, however, imperative that a number of the benefits direct or indirect will go beyond the catchment population. Some of the proposed investments for instance will benefit the general country tourism sector and will lead to increased foreign exchange earnings for the country and thus contribute to the general economic growth of the tourism sector and country at large.

8.3.4 Implementation Mechanism

The implementation of projects proposed can be complex since they require the coordination of a wide range of activities, diverse institutional arrangements, and different time frames. Communities within the catchment are the major implementing agent for the above projects. Other implementing agencies include sub-catchment management committee, KWMZ, Sub-counties, Sub-catchment technical committee, Ministry of water and Environment, Ministry of Agricultural, Animal Industry and Fisheries, Ministry of Tourism, Wildlife and Antiquities, National Environment Management Authority (NEMA), and Development Partners. The priority does not indicate the relevance, but rather an order of implementation in time. The priority is indicated as "critical", "high", "medium" and "low". Critical are activities for which implementation should start immediately, which are conditional to any further implementation and key for sustainable catchment management. Highly prioritised are those activities of high relevance to key issues and with expected high impact on improving water resources management and stopping harmful practices. The activities should be implemented at short term, meaning within 1-3 years from CRAP approval. Medium priority is set for activities that are planned to be implemented at medium term, within 3-5 years from CMP approval. Activities with priority set at "low", can be implemented in the longer term, meaning within 5 to 10 years from CRAP approval

Table 8-10: Implementation matrix

Implementation Period	Short - Term		Medium-Term				Long-Term				
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Sustainable Land and Environmental Management											
River bank Protection and Stabilization											
Multipurpose Storage dams											
Re-afforestation on Farms (Agro-forestry)											
Rehabilitation of existing and new Gravity flow schemes											
Waste Management											
Foot Bridges											

8.3.5 Expected Benefits

- Flood attenuation in the catchment
- Improved soil and water conservation
- Improved water quality
- Providing access to services where no access exists at present. This is likely to relate to access in the rainy season. Providing access to health, education and market facilities is especially important
- Saving time in access to services. Again saving time in access to health, education and market facilities is especially important
- Increasing the amount of produce transported to markets to increase household incomes. Careful assessment is required to obtain realistic estimates based on discussions with the communities and local traders to assess potential for increased household production, potential for increased market sales and the possible impact of increased market inputs on prices.
- Enhanced community livelihoods
- Food availability through irrigation projects
- Improved access to adequate safe water
- Improved vegetation cover

8.3.6 Monitoring and Evaluation

Monitoring and evaluation shall be done by the entire group/association with the help of the other important key stakeholders with key mandate in project implementation. Projects shall be monitored and evaluated regularly within the agreed time frame. Monitoring and evaluation should be participatory in nature i.e. joint effort or partnership of the key stakeholders in a project such as farmers and the extension works to monitor, evaluate and systematically realign the proposed projects.

Table 8-11: Key performance indicators to be used for project monitoring and evaluation

Proposed Projects	Key Performance Indicator	Frequency of Monitoring
Sustainable Land and Environmental Management	▪ Total area conserved (ha)	After every one year
River bank Protection and Stabilization	▪ Length (km) of the river banks protected and conserved ▪ Ha of buffer zones protected	After Six months
Multipurpose Storage dams	▪ Volume (m^3) harvested ▪ Area irrigated (ha)	Annually
Re-afforestation on Farms (Agro-forestry)	▪ Number of trees in the tree nursery	After two years
Rehabilitation of existing	▪ Number of access	After

Proposed Projects	Key Performance Indicator	Frequency of Monitoring
and new Gravity flow schemes	points	every one year
Waste Management	▪ Yield at the disposal site (kg/day)	daily
Foot Bridge	▪ Traffic on the foot bridge	Monthly

8.3.7 Community Contribution

The community will contribute at least 10% of the amount to be used in the project. They will be Monitoring and evaluating, providing cheap Labor and materials for the project to be undertaken while others will be providing land on a voluntary basis for the project. The major contribution above all will be community's Commitment to undertake the projects and implement them on their farm land.

8.3.8 Development Partners

There are various development partners currently operating in Kapchorwa and Bulambuli and also within the catchment (reflecting catchment's priorities towards sustainable development). Development partners provide funding in different forms: capital investment (through concessional loans and grants - CI); budget support (BS); and more commonly, through technical assistance (TA) e.g. specialist advice on project preparation; institutional change management; policy and regulatory reform assistance. At full feasibility study stage, a more rigorous stakeholder/ development partner analysis shall be necessary to identify ongoing projects and programmes by the most active donors in the sector. For now, projects have been designed with existing programmes in mind so as to provide complementarity.

Some of the development partners in the sub-catchment include WWF, Africa Development Bank, GEF, European Union, UK Department for International Development (DFID), GIZ, IUCN, FAO, Mercy Corps, UWA, NFA, OPM and other financial institutions in the sub-catchment.

8.3.9 Project Coordination/ Management

Timely and efficient implementation of the proposed projects will require proper co-ordination and management. Below are some of the stakeholders manage and co-ordinate the implementation of the proposed projects.

- Lower Muyembe Micro-catchment management committee
- Intervention management committees
- Development partners
- Bulambuli and Kapchorwa District Local Governments
- Kyoga Water Management Zone
- Respective Ministries will also play part in coordination of the investments

9 IMPLEMENTATION PLAN

The Implementation Plan (IP) is organised as a practical tool indicating interventions per site, options linked to their activities and sub-activities which need to be implemented in order to achieve the catchment's vision along the three strategic objectives. The options are grouped under the three developed objectives for Lower Muyembe Micro-catchment and therein according to the respective thematic areas under which they fall. Within the thematic areas follow the order of the results of the screening/ ranking (from high to low scores) to reflect their importance. This gives a detailed depiction of which structures should be implemented in which area of each sub-county if applicable under the respective option and at the same time illustrates the most concerned areas for that option.

The IP specifically includes among other things;

- An action plan - a phased and sequenced plan of action in which the priorities and activities to be undertaken in each phase of plan implementation are clearly identified;
- A plan for the "processing" of each project, program and activity in the action plan. Processing typically involves preparation (feasibility study, design, preparation of bills of quantity, tender documents, etc. or other technical activity necessary to implement the activity);
- Identification of who will be responsible for the implementation of each project, program or activity, and what that organization's role will be in relation to the WMZ, the project, and the stakeholder;
- The amount of financing (capital, operating, maintenance) needed, the potential sources of that financing, and identification of who is responsible for securing the financing;
- Identification of changes required in existing policy, laws or regulation to implement the adopted plan; identification of who will be responsible for formulating, preparing and processing those changes;
- A specific, targeted training and capacity building program that is design to directly support the institutions, stakeholders, and beneficiaries of plan implementation.
- Monitoring and evaluation framework. A monitoring and evaluation system required to ensure that the various parts of the implementation of the CMP are on track and that they will lead to the desired outcomes, essentially progress towards meeting the strategic objectives and realizing the vision

Additionally, the IP specifies locations (where applicable), project lead, possible partners for implementation, priorities for implementation as well as structural operation and maintenance on sub-activity level. Some of these aspects are further introduced in the following paragraphs.

9.1 General Prioritization of intervention

The activities are prioritized according to the urgency of implementation. Priority was determined by the availability of funds and implementation capacity (which may have to be created as a part of plan implementation). The priority is defined along the following timeframe (Figure 9-1) based on requirements of targeted donors/financiers ready to put forward to potential financing organizations:

Figure 9-1: Timeframe for defining implementation priorities

9.2 Roles and Responsibilities

The roles and responsibilities of various institutions have been adopted from the Catchment management planning guidelines as summarized in table below

Institution	Roles and responsibilities
KWMZ	▪ Coordinate all implementation activities ▪ Facilitate and support DWRM coordination of central level implementation and financial resource mobilization ▪ Facilitate implementation of catchment plan projects by central departments ▪ Identify modalities for zonal and catchment level implantation among its public and private sector partners ▪ Mobilize funds (Medium Term Expenditure Framework (MTEF), budget, donors, private sector) with the assistance of DWRM for implementation of zonal and micro-catchment level projects ▪ Coordinate, manage and undertake project preparation for zonal and Micro-catchment level plan projects ▪ Assess water use permit applications under existing regulations ▪ Facilitate implementation and installation of upgraded and expanded monitoring network and WIS, and operate system within the zone ▪ Monitor hydrologic and meteorological conditions, compliance with regulations, implementation of sub-and micro-catchment plans and source protection plans ▪ Support and facilitate the continuing role the SCMC and CTC and other stakeholder groups including keeping all stakeholders informed of implementation progress ▪ Undertake secretarial functions for the MCMC.

Institution	Roles and responsibilities
MCMC & CTC	▪ Monitor plan implementation ▪ Promote and facilitate compliance with regulations and permitting system ▪ Facilitate and promote implementation of catchment management and source protection plans ▪ Facilitate inclusion of plan projects and programs into District development plans
MWE - DWRM	▪ Organize and coordinate review of the draft catchment plan and facilitate the Ministry's approval and adoption of the final agreed plan ▪ Organize and coordinate the technical review of plan project proposals and assignment of implementation to the appropriate department ▪ Mobilize funds for plan implementation and AWMZ support ▪ Review policy, legal and regulatory revision needs based on plan recommendations and manage the process for updating and revision
MWE - NEMA	▪ Review the environmental regulatory needs (actions, new or revised regulations) based on the adopted final plan ▪ Issue required regulations, notices, and permits in accordance with legal and regulation requirements
MWE – Line departments	▪ Undertake preparation of projects and investments within their area of responsibility that are proposed in the adopted final catchment plan (feasibility studies) ▪ Supervise and manage project implementation (designs, tender and procurement, construction) ▪ Operate the completed project in accordance with the permit and operating rules agreed with the KWMZ
Line departments in the concerned sector Ministries	▪ Undertake preparation of projects and investments within their area of responsibility that are proposed in the adopted final catchment plan (feasibility studies) ▪ Supervise and manage project implementation (designs, tender documents, procurement, construction) ▪ Operate the completed project in accordance with the permit and operating rules agreed with the KWMZ
District government	▪ Facilitate and support implementation of the adopted final catchment plan ▪ Incorporate priority projects and program into the District development plan as appropriate
Donor partners & NGOs	▪ Implement priority projects and program in collaboration with the AWMZ and stakeholders in accordance with agreements and Memoranda of Understanding with the KWMZ and DWRM
Private sector	▪ Facilitate and support implementation of the adopted final catchment plan

In the implementation, the roles of project lead and implementing partners are differentiated. A project lead takes the initiative or guides an activity that will be implemented. The project lead is not necessarily the funder or the actual implementer on the action. KWMZ/DWRM and the MCMC are the only possible project leads. However, many other actors can be involved in implementation and support.

The project lead should:

- Direct the project implementer to carry out those interventions which are planned for in the CMP.
- Guide the project implementer in stakeholder involvement.
- Provide the project implementer with applicable guidelines and check use.
- Guide the project implementer to set up O&M systems for sustainable use.

Project implementers are implementing partners contributing to the implementation of the activity. Project implementers can again be KWMZ/DWRM, the MCMC, and the district and Sub-county councils, but also other stakeholders. All stakeholder groups, from the water users as primary stakeholders up to development partners and corporate sector can collaborate or contribute resources to the implementation of specific interventions included in the MCMP/CRAP.

Guidance on potential partners is highlighted below. It was extracted from the stakeholder matrix which is included in the Stakeholder Assessment and Engagement thematic report. Involved implementers or partners for each specific activity are included in the implementation plan.

9.3 Investment and Management Actions

Large part of foreseen investment and management actions in the CRAPs are common to all scenarios identified in the option analysis, while some actions are directly related to scenario 1. In some cases, the management actions might be directly related to the costs for design, construction and O&M of all the infrastructures already described, but for most part of them the implementation costs are estimated on the basis of personnel, consultants, stakeholders' meetings / conferences/ workshops and, if needed, also equipment.

These actions are sequenced and prioritized up to the implementation year 2040 and this forms the main body of Lower Muyembe CRAP. While many investment and management actions in this plan are common to all the scenarios discussed in the previous sections, the actions that are directly related to the best ranked scenario; Scenario 1 are summarized below:

Table 9-1: Investment and management actions

Intervention	Action to be implemented
Water resources monitoring network	♣ Groundwater Network ♣ Surface Water Network ♣ Climate Monitoring ♣ Water Quality Monitoring ♣ Sediment Monitoring
Catchment afforestation	♣ Establish and support tree nurseries ♣ Support non-wood, agroforestry and timber tree planting

Intervention	Action to be implemented
Wetland restoration	♣ Verify maps for wetlands ♣ Establish Wetland Management Committees ♣ Development of Community Based Wetland Management Plans including bush fire management ♣ Demarcate wetlands zones (critical zones, protection, buffer zone, production zone for cultivation and settlement) ♣ Develop by-laws and ordinances for wetland protection ♣ Implementation of by-laws and ordinances ♣ Demarcate protected zones (e.g. using trees and/or pillars) in the wetlands and decide/agree permitted activities for the zone ♣ Enforce regulations on unsustainable activities (environmental degradation) in the protected zones ♣ Support traditional leaders to declare some wetlands as traditional shrines and set up traditional/community by-laws ♣ Establish a fund for wetland protection (e.g. community environment conservation fund)
River banks and Lake shores rehabilitation	♣ Identify, map and designate sites where sand or gold mining can sustainably take place ♣ Demarcate buffer zone using live markers ♣ Restore degraded river banks and buffer zones (tree planting, grassing) ♣ River bank stabilization e.g. use of gabions ♣ Build capacity of extension services on soil and water conservation measures (mulching, composting, manuring), good agricultural practices, pest/disease control
Development of water allocation plans	♣ Develop Lower Muyembe Water Allocation Model ♣ Train Staff in the use of the model ♣ Use model in water resources planning at catchment and sub catchment levels
Rainwater harvesting	♣ Promote rainwater harvesting at household levels ♣ Promote rainwater harvesting at institutional level – schools, health centres, faith based institutions ♣ Promote rainwater harvesting at community level
Bulk water transfer schemes	♣ Undertake feasibility and detailed engineering design studies

Intervention	Action to be implemented
	♣ Undertake environmental and social impact assessments ♣ Develop Resettlement Action Plan ♣ Implement feasible schemes
Develop multipurpose water resources infrastructure	♣ Undertake feasibility and detailed engineering design studies for multipurpose water storage infrastructure ♣ Undertake environmental and social impact assessments ♣ Develop Resettlement Action Plan ♣ Implement feasible schemes
Develop piped water supply and sanitation systems	♣ Undertake feasibility and detailed engineering design studies for multipurpose water storage infrastructure ♣ Undertake environmental and social impact assessments ♣ Develop Resettlement Action Plan ♣ Implement feasible schemes
Institutional strengthening and capacity development	♣ Implement MCMC governance system ♣ Support and strengthen the MCMC ♣ Establish technical support team for MCMP/CRAP implementation ♣ Monitoring and evaluation of CRAP implementation ♣ Sub-catchment, Micro-catchment and community action planning ♣ Awareness raising on MCMP/CRAP

9.4 Financing sources

An overview of the main investment programmes and projects in the Water Sector has been carried out in order to evaluate the progress of relevant investment projects. At the local scale, regional and local government projects are undertaken by regional agencies and local government institutions and are funded through the local government financing mechanism (conditional grants).

These projects are not included in the evaluation of main investment programmes and projects in the water sector. Local projects developed by NGOs are also not included in the evaluation of main investment programmes and projects in the water sector

9.4.1 Review of financing mechanisms

Many water financing ‘systems’ have evolved in a pragmatic fashion, with major institutional reforms and innovations arising either from crises or blatant deficiencies in existing systems. However, taking a more principled attitude towards water financing, seeking greater

coherence in the system and conformity with national strategic aims. The search for policy excellence must recognise that there are many 'models' of water financing, reflecting the variety of institutions and governance of water in different countries.

Public financing for water can take various forms which include:

- Allocations from the annual budget of grants for recurrent and capital items entailed in developing or managing water-related assets
- Loans for infrastructure development from government, autonomous public infrastructure funds or publicly owned development banks
- External finance channeled through, or allocated at the discretion of, central government through the Ministry of Water and environment, e.g. AfDB loans, adaptation funds, EU grants
- Public guarantees for commercial loans or private equity (various kinds of 'off balance sheet' finance, such as financial guarantees, off-taker agreements, etc., which are a contingent liability for the national exchequer)
- Subsidies targeted at water users or specific service providers, including the encouragement of in-kind and self-funding initiatives.

These five categories of finance criss-cross the various water domains. Governance is typically funded largely or wholly from government budgetary grants. At the other extreme, water user services tend to recover a portion of their costs from consumers, with the balance made up from government subventions or targeted consumer subsidies. The stewardship aspect of WRM and development shows great variety in its forms of finance, with many hybrids and combinations.

These sustainable financing mechanisms can only be achieved through an accurate prediction of the resources' availability and the expansion of projects to improve water services within the catchment. Availability of timely and sufficient financing also heavily determines how an institution will deliver on its mandates. Currently the cost of the WMZ, the CMOs and the catchment planning process are covered by the DWRM through the (donor supported) MWE budget and MoUs with implementing NGOs.

For the KWMZ, key sources of financing currently include GoU, World Bank, AfDB and the Joint Partnership Fund (Austrian Development Cooperation, DANIDA, and others). Some development partners as highlighted in Section 7.2 also finance catchment-based WRM interventions. The key concern is that existing financial resources are insufficient, sometimes characterized by budget cuts.

Support for the CMOs is mainly in-kind through the WMZ Teams, for example: Information, such as maps and charts, to inform stakeholders, Technical guidance and support, based on the results of KWMZ planning & analysis brought into forms that are readily understood by laymen, Secretariat services such as organization, scheduling, meeting services (venues, catering etc.), and documents (including videos, slides, reports, etc.), Training and capacity building of CMO members and participants, including the initial mobilization and organization of the CMO, and Logistical support including travel and meeting costs.

Often, what is budgeted is also not actually realized, demonstrating inconsistency and unreliability in flow. The releases usually delay, and even once received, sometimes processing of funds takes longer than anticipated owing to internal bureaucracies. The GoU

funding contribution has also not yet been realized at zone level because of lack of a dedicated bank account.

The opportunity is that government and development partners seem to be committed to funding catchment-based WRM, and that this is only the beginning. Many other partners' interventions (e.g. WWF, NFA, WSDF, TSUs, Umbrella Organization etc.) could also leverage resources if good collaboration and networking arrangements are put in place.

9.4.2 Main financing sources

The implementation of the CMP plan will require funding from different sources, according to the type of action/ intervention and of the relevant sectors involved in the implementation. These include mainly five sources: Water and Environment Sector Budget, Joint Partnership Fund (JPF), Sector Budget Support (SBS), off budget operations, and Private sector investments.

The Ministry of Water and Environment shall support implementation of the MCMP through the Water and Environment Sector Budget, including direct field investments or promotion of investments from other institutions and development partners, enabling and coordination activities, training and capacity building, communications/ awareness and stakeholder outreach and engagement activities, as well as procuring the recommended equipment, facilities and human resources.

The engagement of the private sector in the management and development of water infrastructure and services is a key factor for the successful implementation of the CMP. Private actors might include either international or national, regional and local operators, as well as joint ventures among private operators with public institutions or utilities. The private sector can develop and implement a wide range of projects and activities in the Water and Environment Sector.

Public Private Partnerships (PPPs) are considered as an important tool in Uganda's plan to bridge the infrastructure financing gap in the next years. The PPP Act, passed in 2015, provides methods for procurement and the engagement of private partners in PPPs. It also regulates the roles and responsibilities of government bodies during the development and implementation of PPP projects. The PPP Act established two PPP agencies: the Public-Private Partnerships Committee as well as the Public-Private Partnerships Unit (within the Ministry of Finance, Planning and Economic Development). Furthermore, the vital role of not-for-profit systems (like CBOs) shall be included in the private sector contribution to the implementation of the catchment WRDM plan.

9.4.3 Preliminary strategy for investment interventions

The harmonisation, mainstreaming and accountability of the implementation of the CRAP will be integrated within the existing cross-sectoral coordination framework for Water and Environment Sector funding. The Water and Environment Sector Working Group (WESWG) shall supervise the development of cross-sectoral programmes and sub-programmes of the WRDM Strategy and ensure harmonised implementation in line with the JWESSP objectives where non earmarked funding is provided through the JPF. The government and the Ministry of Water and Environment shall be responsible for defining and establishing the institutional and financial framework for enabling the participation of the private sector in the

implementation of CMP, overseeing its functioning and ensuring the provision of water-related public goods and services. In view of the monopolistic character of the water sector, regulation and oversight of tariff setting is paramount.

For domestic water supply interventions, the larger part of financial need is expected to be provided by IFIs and in particular by the International Development Association (IDA), one of the agency of World Bank Group supporting developing countries. The development finance support given by IDA is in the form of very long-term loans (around 35–40 years), with long grace periods (up to 10 years) and with no interest payment, which is replaced by an annual servicing fee (0.75%).

As already indicated in the "Water for Production Strategy and Investment Plan" (DWMR, 2009), it is foreseen that for livestock facilities 30% of the investments are carried out by commercial ranches directly and/or as subsistence livestock owners' contributions. For irrigation facilities, the off-farm investments in water supply infrastructure are carried out by the water sector, while all on-farm investments are done by the farmers or commercial enterprises. For aquaculture, only 1% of the total investment in aquaculture facilities is financed by the water sector.

Multipurpose reservoirs have to be developed under the traditional model of a governmental agency or a public utility managing the various phases of the project life cycle. Multipurpose reservoirs and other storages facilities can have significant objectives and associated benefits in many sectors: besides water supply, irrigation, hydroelectric production, and aquaculture, they help the maintenance of water quality and environmental flows, flood and climate change mitigation, but also tourism and leisure facilities. Therefore, multipurpose hydro projects need to be funded by public resources, drawing on IFIs aid when needed. The hydropower component could be room for private involvement in partnership with the public sector in multipurpose projects where an acceptable balance between risks and rewards can be achieved between the various stakeholders.

Suggestively, KWMZ can opt for a conditional permit fee exemption or reimbursement scheme. Under such a system, individuals or companies (like Nexus Green Ltd, BADEA)) required to pay a permit fee for water abstraction may apply for an exemption (or later reimbursement) if they can prove to have invested in good catchment management. When combined with MCMC membership, that is, contributions to MCMC activities are recognized and permit fee exemption is only granted for activities within the catchment management plans, it is also a strong incentive to participate in joint catchment management. Besides effectively retaining available funds near their point of generation, it is also believed that once the positive effects are recognized by these water users, additional investments will be added voluntarily (for example through Payment for Ecosystem Services schemes).

The community is envisaged to contribute at least 10% of the amount to be used in the project through provision of cheap labour and land on a voluntary basis for the project.

Pre-feasibility costs are typically around 1.5% of capital costs and feasibility phase is about 3%. Design and construction supervision costs are estimated at 10% therefore for the proposed infrastructures the overall costs for personnel, consultants and meetings/ workshops are around 14.5% of capital costs.

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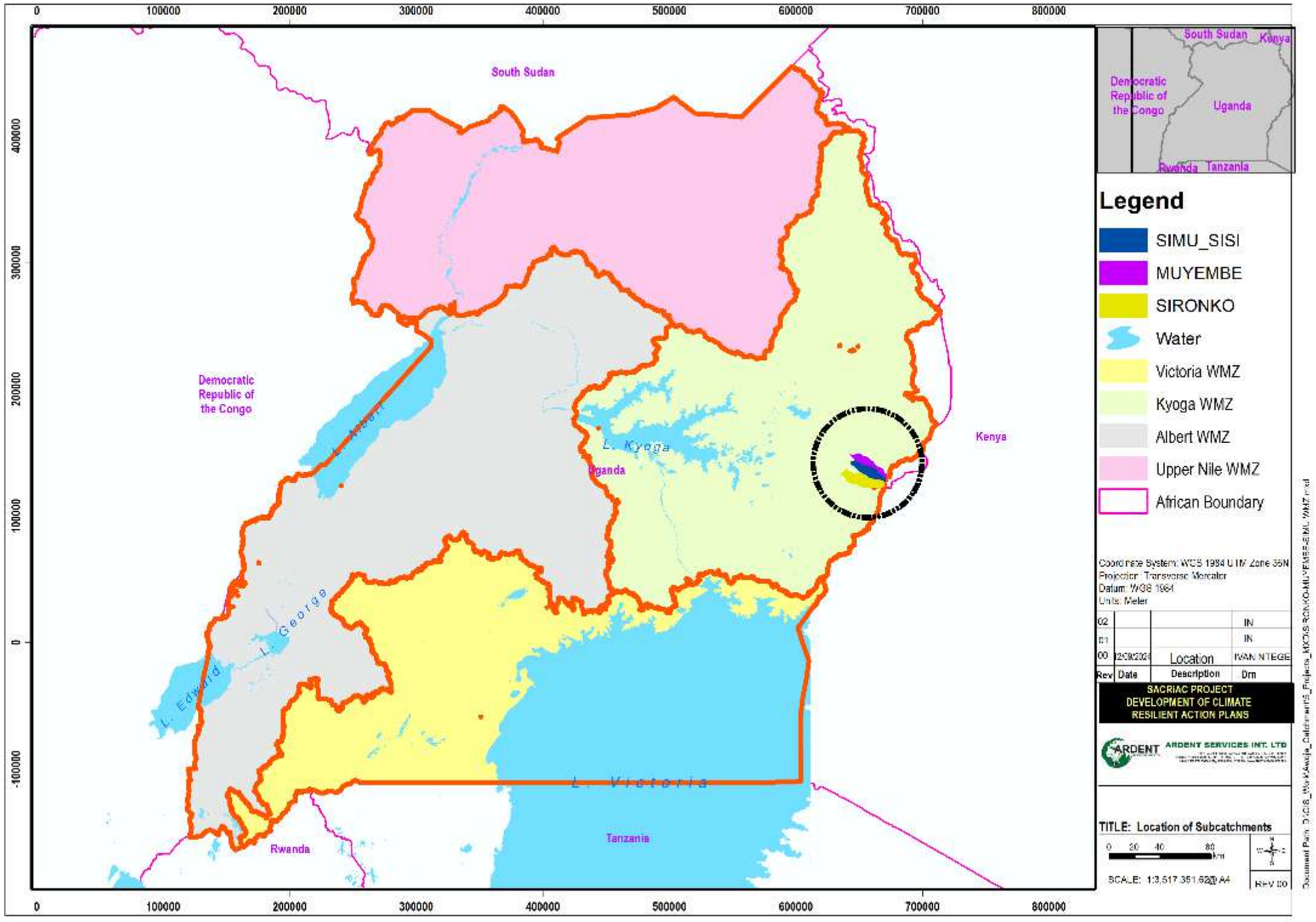
APPENDICES

Annex A : Lower Muyembe micro-catchment management committee members

	Lower Muyembe Micro-catchment management committee				
No	**Name**	**Position**	**Sex**	**Contact**	
1	Busiku Jimmy	Chairperson	M	0779378697	 Members of Lower Muyembe MCMC Given Name: **Lower Muyembe Micro-catchment management committee**
2	Mutonyi Agatha	PEC/Sec	F	0775731140	
3	Namataka Susan	WUC Rep	F	0787154026	
4	Gudoi Abdu	Religious Rep	M	078304532	
5	Namukasa Asha	Women Rep	F	0775327334	
6	Kalisi Jimmy	Youth Rep	M	0780756452	
7	Neumbe Rosemary	Elderly Rep	F	0701458826	
8	Wakaata Damascus	PWDs Rep	M	0787154026	
9	Nagudi Oliver	CBO Rep	F	0773816417	
10	Namusi Moses	Member	M	0788310154	
11	Munga Rose	Member	F	0779240202	
12	Namono Justine	Member	F	0767373264	
13	Neumbe Ketty	Member	F	07669505517	
14	Nakimolo Gerald	Member	M	0782582537	
15	Watoya Ronald	Member	M	0777666542	
16	Shimwende Steven	Member	M	0779799082	
17	Namwaki Scovia	Member	F	0787666295	
18	Kakayi Betty	Member	F	0782228620	
19	Mwolobi Violet	Member	F	0761031300	
20	Musumali Nathan	Member	M	0781151048	
21	Nabakye Lydia	Member	F	0777133049	
22	Wakooli Loy	Member	F	0784007905	
23	Mukoya Topister	Member	F	0782643993	

	Lower Muyembe Micro-catchment management committee				
No	**Name**	**Position**	**Sex**	**Contact**	
24	Napakoli Bosco	Member	M	0773652520	
25	Wanyakala George	Member	M	0789486506	
26	Kanyanya Alex	Member	M	0788825013	
27	Musuya Sarah	Member	F	0784900868	
28	Kibone Alice	Member	F	0779300872	
29	Wabulo Harriet	Member	F	0784002233	

Annex B : Location map of Lower Muyembe micro-catchment within the Kyoga water management zone



Annex C : Investment Plan

S/N	Micro-Catchment Name	Sub-Basins within the Micro-Catchments	Physical /Political boundaries within micro-catchment	Priority components	Estimated Investment Costs (USD)
1	**Lower Muyembe**	Muyembe Sub-catchment	R. Muyembe, R. Gibuzali, R. Sirimityo, & R. Nabongo.	Agro-forestry	93,000.00
2				Sustainable land and Environment management cost	41,358.18
3				River bank protection and stablisation	249,847.00
4				Waste management	500,000.00
5				Rehabiltation of existing and new Gravity Flow scheme	300,000.00
6				Multipurpose storage dams	466,000.00
7				A foot bridge	800,000.00
	TOTAL ESTIMATES (USD)				**2,450,205.18**

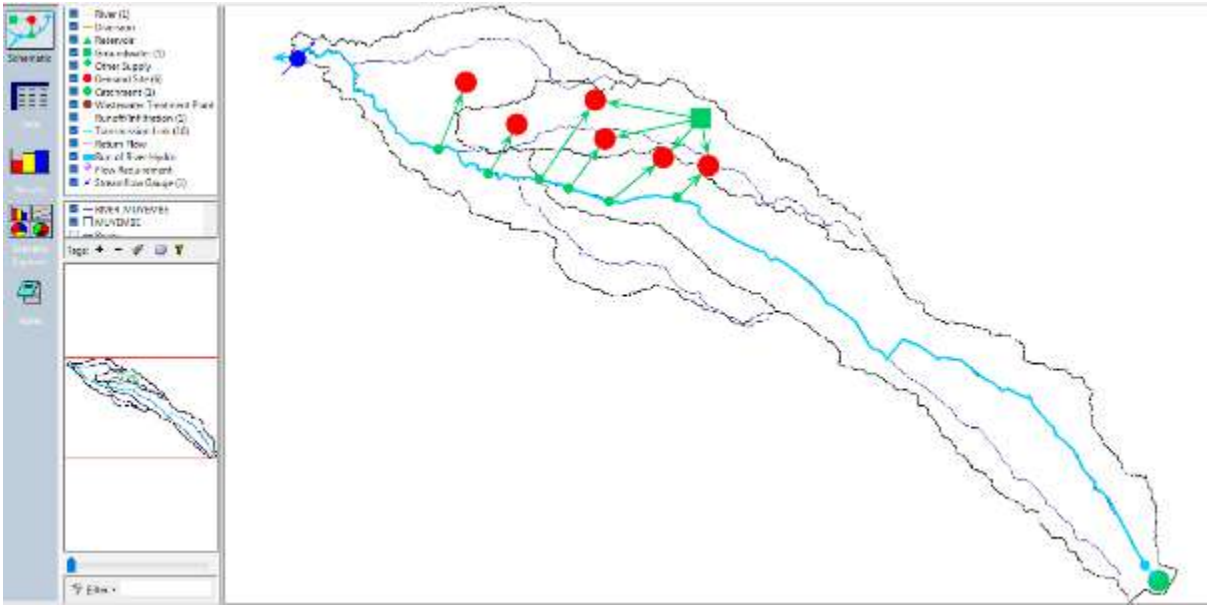
ANNEX D : Parameter ranges and best fit values

Parameter	Description	Initial Range	Best Fit Value	Impact on the Model
Crop Coefficient, Kc	When it rains, how much water can potentially be evapotranspirated by plants?	0-1000	Agriculture – 1.05830 Forest – 1.22722 Grassland -1.02196 Wetland – 1.1 Water – 1.06566 Buitup – 0.70275	Increases in Kc lead to more evapotranspiration – a net loss of water from WEAP's accounting system, and loss of water that could contribute to streamflow
Runoff Resistance Factor (RRF)	Of the water that is not evapotranspirated, do the conditions on the surface, such as leaf area and slope, drive or hinder percolation.	0-20	Agriculture – 5.186867 Forest – 2.25772 Grassland -5.86295 Wetland – 1.1 Water – 1.03455 Buitup – 0.06642	Increasing allows less water to become streamflow as it instead percolates into the soil immediately. While it is in the soil, more evaporation is possible – enabling a higher water loss from WEAP's accounting system and loss of water that could contribute to streamflow
Root Zone Conductivity (Ks)	The water that infiltrates into the ground moves first into the "upper bucket" of the model. There the water is subject to several parameters. How fast does water move through the upper bucket. Root zone conductivity rate at full saturation, which is partitioned between interflow and flow to the lower soil layer.	0-10000	Agriculture – 7043.83 Forest – 7919.23 Grassland -8583.53 Wetland – 100 Water- 175.458 Built-up – 713.890	Increasing will shorten travel time for any water in the upper soil layer (less evaporation possible, less loss of water from the system)

Parameter	Description	Initial Range	Best Fit Value	Impact on the Model
Soil Water Capacity (Sw)	How much capacity (mm multiplied by the area of the land use type, defined in Land use/ Area data) does the upper soil layer have to hold water? Effective water holding capacity of upper soil layer	0-1000	Agriculture – 940.1021 Forest – 786.385 Grassland -926.827 Wetland – 700 Water – 465.2 Built-up – 44.7234	Increasing will increase travel time for any water in the upper soil layer (more evaporation possible, more loss of water from the system
Preferred Flow Direction (f)	As the water travels through the upper soil layer, how much of it percolates into the lower layer, and how much of it runs off and becomes streamflow	0-1	0.10438	0= all water leaving the upper soil layer flows to the lower soil layer, and none to river 1= all water leaving the upper soil layer flows to river, and none to lower soil layer
Deep Water conductivity (Kd)	Any water in the upper soil layer that moves to the lower layer has parameters defining how it behaves: What is the speed that the water moves through the lower soil layer. Conductivity rate (length/time) of the deep layer at full saturation, which controls transmission of base flow.	0-1000	257.952	Increasing will shorten travel time for any water in the lower soil layer before it flows into the river. There is no evaporation in the lower soil layer.

Parameter	Description	Initial Range	Best Fit Value	Impact on the Model
Deep Water Capacity (Dw)	What is the capacity (mm) of the lower soil layer? Effective water holding capacity of lower, deep soil layer	1-500	121.673	Increasing will increase travel time for any water in the lower soil layer before it flows into the river
Initial Z1/ Initial z2i		0-100	27.5168%/81.938%	Initial conditions determine the amount of water that is already available in the top/ deep soil layer and affects what happens to the new water that reaches the layer. It drastically affects the response in the first year, after which it tends to adjust itself. The percentage of soil moisture must be relatively stable over time, except in the very extreme circumstances. The result of the first run is used to set the initial z2

ANNEX D : Schematic View of the WEAP model for Muyembe sub-catchment



Annex E : Water Quality Certificate

Republic of Uganda

MINISTRY OF WATER AND ENVIRONMENT
MBALE REGIONAL WATER QUALITY LABORATORY

Certificate of Analysis

Client Name : Ardent Services International Ltd
Client Address : Plot 4 Ardent House, Gayaza High Avenue, P.O.Box 111680
Sample type and condition : Surface water, received in 1.5ltr Mineral water Bottles
Sample by : Client
Date Sampled : 23/05/2025 Date received :23/05/2025
Analysis Start date : 23/05/2025 Analysis Completion date :13/06/2025

TEST RESULTS

Source Name	Units	Sirimityo	Lower Simu	Mid Sironko	Lower Sironko	Upper Muyembe	Lower Muyembe	Upper Sironko	Mid Sironko
District		Kapchorwa	Bulambuli	Sironko	Sironko	Bulambuli	Bulambuli	Sironko	Sironko
Easting		310738	185830	191172	236052	298602	282341	151470	155940
Northing		330384	322694	316849	257249	287349	304312	368752	361271
Lab Identifier code		MBL 25/0388	MBL 25/0389	MBL 25/0390	MBL 25/0391	MBL 25/0392	MBL 25/0393	MBL 25/0394	MBL 25/0395
pH	pH Units	7.8	8.0	8.1	8.2	8.0	8.1	8.2	8.1
Electrical Conductivity	µS/cm	116	126	271	181	130	125	269	112
Total Dissolved Solids	mg/l	81	88	190	127	91	88	188	78
Colour	PtCo	464	238	289	2650	370	283	355	171
Turbidity (NTU)	NTU	81.6	42.1	49.1	177.0	67.8	47.5	48.0	28.7
Total Hardness as CaCO3	mg/l	68	66	125	93	67	71	115	71
Calcium hardness as CaCO3	mg/l	37	40	80	64	39	34	95	34
Magnesium hardness as CaCO3	mg/l	31	26	45	29	28	37	20	37
Calcium	mg/l	15	16	32	26	16	14	38	14
Magnesium	mg/l	7	6	11	7	7	9	5	9
Total Alkalinity	mg/l	58	63	150	95	69	69	135	58
Bicarbonates	mg/l	71	77	183	116	84	84	165	71
Sodium	mg/l	2.6	4.8	14.8	7.0	3.7	3.7	12.6	2.6
Total Nitrogen	mg/l	2.054	1.084	1.223	1.424	0.99	0.821	2.306	1.362
Total Phosphorous	mg/l	0.370	0.11	0.15	0.28	0.08	0.13	0.21	0.11
Aluminium	mg/l	0.241	0.560	0.311	5.515	0.459	0.481	0.593	0.214
Nitrates as N	mg/l	1.589	0.96	1.006	1.21	0.637	0.771	1.831	0.088
Nitrites as N	mg/l	0.005	0.005	0.027	0.015	0.019	0.011	0.011	0.008
Total Suspended Solids	mg/l	69	30	34	128	48	27	40	17

Note: 1. This certificate shall not be reproduced without approval of the Laboratory
*2. **Test result from sub-contracted Laboratory.*
3. Analysis site is Mbale Regional Water Quality Laboratory

Disclaimer
- These results relate to the sample as received.
- Details of the sample with respect to source and representativeness is the responsibility of the client.
- This certificate of analysis does not substitute certification of a business or product by other relevant authority.

Checked by: LABORATORIES MANAGER 13 JUN 2025 REGIONAL WATER QUALITY LABORATORY - MBALE

Ministry of Water and Environment
Mbale Regional Water Quality Laboratory
Kyoga Water Management Zone
P.O.BOX 1324, Mbale
Plot 14, Works Road

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Sign:.....

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